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# Appendices

## **Appendix A.** Content of local ICT policy plans and illustrations of content per subcategory

| Category and subcategory of local ICT policy plans content | Illustrations of content for the subcategories |
|---|---|
| **1. Vision** | |
| 1.1 Development background | e.g., The ICT infrastructure construction is lower than the national average level. The broadband speed in more than 50% of the compulsory education schools in the towns or villages is less than 10 Mbps, and the sharing level of resources is low. The principals' ICT leadership and teachers' ICT skills need to be improved, and the effect of ICT use is not high. (Policy A) |
| 1.2 Development goals | e.g., By 2020, establishing an ICT service system for anyone to learn anywhere and anytime, which is consistent with the goal of educational modernisation. (Policy B) |
| **2. Expertise** | |
| 2.1 Teachers' ICT skills improvement | e.g., Carrying out the training on teachers' ICT use, capacity to improve teachers' capacities of instructional design, content presentation, and teaching evaluation. (Policy B) |
| 2.2 Leaders' ICT leadership and skills' improvement | e.g., Conducting training on ICT leadership and ICT skills to enhance leaders' capacities for ICT planning, management, and execution. (Policy C) |
| Students' ICT literacy improvement | e.g., Strengthening student ICT use capacity and self-learning capacity, and improving students' modern ICT literacy. By 2020, 90% of students could use ICT for autonomous learning. (Policy B) |
| **3. Digital content** | |
| 3.1 Quality digital educational resources construction | e.g., Introducing high-quality resources of schools, enterprises and institutions, and developing the educational resources for basic education. (Policy A) |
| 3.2 Digital educational resources public service platform construction | e.g., Promoting the interconnection of local-level platforms and national platforms to develop an educational resources public service system. (Policy A) |

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| 3.3 Educational management public service platform construction | e.g., According to the requirements of the Ministry of Education, accelerating the completion of the local-level construction of the educational management public service platform. (Policy B) |
| 3.4 E-learning space construction | e.g., Accelerating the construction and use of "e-learning space for everyone" through purchasing services by the governments and schools. (Policy A) |
| 3.5 Educational service portal and integrated business support cloud platform construction | Descriptions of the construction of an educational service portal and integrated business support cloud platform. (Policy B) |
| 3.6 E-Governance improvement | e.g., By 2020, building a decision-making service system based on educational big data. (Policy B) |
| **4. ICT Infrastructure** | |
| 4.1 Descriptions of the Internet | e.g., By 2020, the average export bandwidth for classes in urban schools that access to the education metropolitan area network will not be less than 30Mbps, the average export broadband for classes in rural schools will not be less than 10Mbps, and the average export broadband for classes in teaching points will be more than 8Mbps. (Policy B) |
| 4.2 Descriptions of computers allocation | e.g., Implementing the construction of computer network classrooms in primary and secondary schools based on the project "comprehensive improvement of basic conditions for weak schools in compulsory education". (Policy A) |
| 4.3 Descriptions of multimedia teaching equipment | By 2020, all schools will be equipped with multimedia equipment in compulsory education. (Policy A) |
| **5. Leadership** | |
| 5.1 Involvement | e.g., Promoting the Chief Information Officer (CIO) system at all levels of schools to guide a school's ICT development. (Policy B) |
| 5.2 Assessment | e.g., Incorporating the work of ICT in education into the annual assessment of districts and schools. (Policy B) |
| **6. Support** | |
| 6.1 Pedagogical support | e.g., Constructing 1,000 pilot schools and 50 pilot districts of good practices in ICT use. (Policy A) |
| 6.2 Technical support | e.g., Accelerating the construction of a professional team. (Policy A) |
| 6.3 Financial support | e.g., Increasing the financial support for ICT in education in rural and remote areas. (Policy C) |

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| **7. Collaboration** | |
| 7.1 Global collaboration | e.g., By 2020, establishing three Chinese-foreign cooperative research institutions for ICT in education, and developing 200 ICT leaders and educational experts with international vision. (Policy C) |
| 7.2 Regional and industry collaboration | e.g., Integrating the resources of different departments and forming a joint force to provide quality, convenient and efficient services for schools, teachers, and students. (Policy A) |
| **8. Pedagogical use of ICT** | |
| 8.1 Innovative use of emerging technologies | e.g., Conducting a variety of learning experience activities for students by using virtual reality, 3D printing, intelligent robots, and other technologies. (Policy C) |
| 8.2 Pedagogical approach changes | Promoting the transformation of teaching mode (e.g., situational teaching method, project-based learning, and flipped classrooms). (Policy B) |

## **Appendix B.** Rural schools' ICT practices: Summary of categories and sample quotations per subcategory

| Category and subcategory of ICT practice | Description | Sample quotations |
|---|---|---|
| **1. Shared vision and school policy** | | |
| 1.1 Purposes for ICT use | To improve teaching quality and efficacy. | I hope that teachers can use ICT as much as possible to effectively serve classroom teaching. (Leader, School A-03) |
| | To promote student learning. | Because the effect of the animation is very intuitive, primary school students prefer it. (Teacher, School B-05) |
| | To create "digital schools" or "smart schools" according to the local ICT policy plans. | According to the unified arrangement of the Center for Educational Technology, our school will carry out the creation of "digital schools". (Leader, School C-02) |

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|---|---|---|
| 1.2 Schools' ICT policy plans | No ICT policy plans were available in ten schools. | The policy plans are not yet available. Mainly in accordance with the requirements of the Center for Educational Technology, we organise training twice a year and then upload the training video to indicate that we implement the practice. (Leader, School C-07) |
| | Schools' ICT policy plans were presented in other plans (e.g., teaching and research work plan, curriculum reform plan, reporting materials in nine schools. | Specialised ICT policy plans are not yet available, but they are presented in the annual teaching plan. (Leader, School C-01) |
| | Specialised ICT policy plans were available in six schools. | We have a five-year plan for the development of ICT, from 2010 to 2015. Because of the lack of guidance, we did not update it. (Leader, School C-06) |
| **2. Expertise** | | |
| 2.1 Teachers' knowledge and skills in ICT | Teachers were provided with training at different levels in how to use ICT (e.g., electronic whiteboard, multimedia courseware, and digital resources platforms). | All teachers have received training from the "National Primary and Secondary School Teachers ICT Application Capacity Improvement" project. (Leader, School B-04) |
| | Teachers had difficulty in using advanced technologies. | Video is video, PowerPoint is PowerPoint, and how to integrate videos into PPT is not only a technical problem. If this problem is solved, the teacher's ability to apply ICT will be highly improved. (Leader, School B-07) |

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| 2.2 Teacher attitudes toward using ICT | Most teachers had positive attitudes toward ICT because of the benefits of using ICT. | Embedding audio and video clips in the courseware could be very helpful for the students to concentrate, so I like them very much. (Teacher, School A-02) |
| | Some teachers worried about the side effects of ICT on students. | I teach mathematics. I feel that excessive use of ICT will affect the development of abstract thinking and hands-on ability of middle school students. (Teacher, School A-06) |
| **3. Digital content** | | |
| 3.1 Sources | Search engines, colleagues or friends, school teaching resources, and digital resources platforms, commercial database, etc. | The education bureau has signed agreements with many publishers. We just need to log in to the public service platform, and many resources are available for us to download. (Leader, School A-03) |
| 3.2 Types | Multimedia courseware, multimedia material, electronic lesson plans, teaching cases and videos of famous teachers, and question bank, etc. | The resources we use include lesson plans, courseware, test papers, learning plan, and classroom recording videos. (Leader, School C-08) |
| 3.3 Relevance to teaching | Digital content that was consistent with the textbook version was the most relevant. | The CD-ROM for the teacher's reference book we bought is most relevant to teaching because it is most closely integrated with the textbook. (Leader, School B-01) |

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| **4. ICT infrastructure** | | |
| 4.1 Computers | The computers and/or multimedia equipment were purchased by the national project, local education bureaus and/or the school. | There are 51 teacher and student computers, most of which are distributed by the national project. The school mainly purchases laptops for teachers. (Leader, School A-05) |
| | There were public computers in teacher offices, but not all teachers had their own personal computers. Student computers were available in computer classrooms. | There is a desktop and a laptop in each office, shared by 3 to 4 teachers. (Leader, School B-04) The student computers are in the computer classroom, about 60, and a few are too old and broken. (Leader, School B-05) |
| 4.2 Multimedia equipment | Multimedia equipment was available but the quality of some was not good. | The clarity of the electronic whiteboard is not high, so the students in the back row cannot see it very clearly. (Teacher, School C-08) |
| 4.3 Internet | The internet involved unified planning by the local authorities and was purchased by the school. | We are connected to the metropolitan area network of the Education Bureau, but sometimes the internet speed is not good. (Leader, School C-05) |
| | Wi-Fi was available in some schools. | Teachers' mobile phones can be connected to Wi-Fi anywhere in the school. (Teacher, School C-03) |

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| **5. Leadership** | | |
| 5.1 Involvement | The overall participation was high. | The principal leads the academic affairs office, and the academic affairs office leads the grade leaders and the teaching and research team leaders. It is a top-down guarantee mechanism. (Leader, School B-09) |
| | Most schools set up a leadership team or information centre. | The general director is responsible for hardware management and the director of the academic affairs office is responsible for the use. (Leader, School B-03) |
| 5.2 Prescription | Teachers must use multimedia equipment in some cases. | Teachers are required to use electronic whiteboards in teaching competitions. There is no prescription on which digital content to use. (Leader, School C-01) |
| | Teachers had options to use various resources for their lessons but recommendations were given by some principals. | The principal sometimes recommends websites such as Onion Math, Middle School Chinese Network. (Leader, School A-06) |
| | Some schools request teachers to record their usage. | Teachers who teach in the function classroom need to record their usage on the platform. (Leader, School B-08) |
| 5.3 Assessment | The leadership team is responsible for the assessment of teaching with ICT. | The principals and directors have to listen to 20 lessons per semester, examining the teacher's teaching level and the use level of ICT. (Leader, School A-05) |
| | The leadership team (e.g., academic affairs office) is also responsible for the assessment of digital lesson plans. | The assessment is in the form of submitting digital lesson plans by teachers. (Leader, School A-01) |

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| 5.4 Teacher professional development strategies | Making the training content specific. | The ways of using ICT may differ in different disciplines, so teachers need to get the training related to their subjects. (Leader, School A-06) |
| | Strengthening supervision in training and post-training assessment. | If the teaching assessment is unqualified, the performance bonus will be deducted, a lot, tens of thousands of yuan a year. (Leader, School B-05) |
| | Setting good examples for other teachers to prove that ICT can improve teaching quality. | I think the first strategy is still typical propaganda. The role of the role model is endless. If teachers are forced to use it, this may be counterproductive. (Leader, School C-01) |
| **6. Support** | | |
| 6.1 Pedagogical support | Teachers were encouraged to switch from traditional teaching methods to ICT-based teaching methods. | In the school conference, I encourage all the old teachers to use ICT because it is good for their health and improving work efficiency. (Leader, School B-03) |
| | Principals and directors of teaching took the lead in the use of ICT in the main subjects. | Leaders take the lead in making courseware and providing teachers with ideas on the use of ICT in school teaching and research activities. (Teacher, School A-02) |
| | School leaders provided pedagogical supports outside schools. | When new technologies are introduced in the school, we will provide the opportunity to study outside school with teachers. (Leader, School B-08) |

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| 6.2 Technical support | Teachers had access to internal support from ICT teachers but the support was quite limited. | Only one teacher in our school who is responsible for equipment maintenance. (Leader, School B-06) |
| | Teachers had access to external support from the superior maintenance department and computer company. | When we encounter big technical problems, the company we hired will fix them. (Leader, School B-02) |
| 6.3 Financial support | Schools purchased digital content (e.g., commercial resources, management platform). | Since 2012, our school has purchased commercial resources and shared them in school. (Teacher, School C-08) |
| | Schools purchased digital equipment. | In 2008, the school raised 300,000 RMB and purchased 12 sets of electronic whiteboards. (Leader, School A-01) |
| **7. Collaboration** | | |
| 7.1 Collaboration within-schools | Teachers who teach the same subject shared resources (e.g., courseware, practice questions) with colleagues. | The digital content made by each teacher is required to be uploaded to the school's resource library for sharing. (Leader, School B-01) |
| | Teachers who teach in the same subject work together to prepare for lessons. | The teachers prepare for lessons together using No.7 Middle School's recording class resources or self-made resources. (Leader, School C-06) |
| | Teachers in the same schools shared ideas in teaching and research activities. | Colleagues exchange ideas about the development of school courses, for example, Maker. (Teacher, School C-03) |

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| 7.2 Collaboration across- schools | Teachers prepared lessons together across-schools in the same district. | There are not many psychology teachers, so the psychology teachers in our district have to prepare lessons together. (Teacher, School B-07) |
| | Teachers in union schools shared resources and ideas. | We and other schools conduct teaching and research activities through videoconferencing. (Leader, School B-01) |
| | Teachers in some primary schools teach lessons synchronously. | We work with other two schools in villages to conduct music lessons synchronously in order to help those schools who are short of music teachers. (Leader, School A-03) |
| **8. Pedagogical use of ICT** | | |
| 8.1 Types of multimedia classroom | There are six multimedia classroom configurations. | One interactive LCD panel + one booth (eight schools);<br>One interactive LCD panel + one booth + two projectors (two schools);<br>One projector + one electronic whiteboard + one booth (eight schools);<br>One projector + one electronic whiteboard + one booth+ one television (three schools);<br>One projector + one curtain + one booth (two schools);<br>One television+ student computers (one school). |
| 8.2 Most used digital content | Most teachers used electronic lesson plans to prepare lessons and use multimedia courseware and materials to implement lessons in their classroom practices. | |

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| 8.3 Most used ICT infrastructure | Most teachers used interactive electronic whiteboard and projection booth in class. |
| 8.4 Pedagogical approach | Most of these lessons tended to be teacher-driven focusing on knowledge transfer. |

## **Appendix C.** Overview of the measurements and their constituting items

| Variable | Item |
|---|---|
| Attitude | Please indicate how much a particular item applies to you as a teacher:<br>1. Because of the use of digital educational resources, I am more satisfied with my work.<br>2. I like to use digital educational resources in my teaching.<br>3. Students are more motivated for my teaching when I use digital educational resources.<br>4. Because of the use of digital educational resources, my teaching becomes more efficient.<br>5. Teaching with digital educational resources in an effective way inspires me.<br>6. The use of digital educational resources improves my teaching.<br>7. I can teach with digital educational resources without the help of others.<br>8. I am able to apply digital educational resources in class.<br>9. I learn to use digital educational resources in teaching quite fast.<br>10. I am able to use digital educational resources in class in an effective way.<br>1 (*absolutely inapplicable*) to 7 (*absolutely applicable*) |
| Self-efficacy | Please indicate how much a particular item applies to you as a teacher:<br>1. I doubt my ability to use digital educational resources in teaching.<br>2. If students have questions about digital educational resources, I am unable to help them.<br>1 (*absolutely inapplicable*) to 7 (*absolutely applicable*) |

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|---|---|
| Subjective norm | Please indicate how much a particular item applies to you as a teacher:<br>1. In our school, digital educational resources have an important place in teaching.<br>2. Our school vision clearly describes teaching with digital educational resources.<br>3. In our school, teaching with digital educational resources is appreciated.<br>4. My colleagues think teaching with digital educational resources is important.<br>5. In my work context, teaching with digital educational resources is perceived as important.<br>6. Our school leaders pay a lot of attention to the use of digital educational resources in teaching.<br>1 (*absolutely inapplicable*) to 7 (*absolutely applicable*) |
| Knowledge and skills | Please indicate how you feel about a particular item:<br>1. I can choose digital educational resources that enhance the teaching approaches for a lesson.<br>2. I can choose digital educational resources that enhance students' learning for a lesson.<br>3. I think deeply about how digital educational resources influence the teaching approaches I use in my classroom.<br>4. I can reflect on how to use digital education resources in class.<br>5. I can use digital educational resources in various teaching activities.<br>1 (*strongly disagree*) to 7 (*strongly agree*) |
| Facilitating conditions | Please indicate how you feel about a particular item:<br>1. A specific person is available to provide assistance.<br>2. Guidance is available to me in selecting digital educational resources to use.<br>3. I know where to seek assistance.<br>4. Specialized instruction concerning digital educational resources is available to me.<br>5. I am given timely assistance.<br>1 (*strongly disagree*) to 7 (*strongly agree*) |
| Intention | Please indicate how much a particular item applies to you as a teacher:<br>1. I plan to use digital educational resources in class.<br>2. I intend to use digital educational resources in class.<br>3. I should use digital educational resources in class.<br>4. I will use digital educational resources in class.<br>1 (*absolutely inapplicable*) to 7 (*absolutely applicable*) |

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|---|---|
| Actual behavior | Please indicate how often you use the following types of digital educational resources in your teaching:<br>1. Multimedia Courseware,<br>2. Multimedia material (text, pictures, animation, video, audio, etc.),<br>3. Electronic lesson plans / instructional design,<br>4. Teaching cases and videos of famous teachers,<br>5. Question bank/ test papers,<br>6. Microlecture/ microvideo,<br>7. Subject software and tools (Geometry, virtual lab, etc.),<br>8. Online Course,<br>9. Thematic page/website,<br>10. E-books/periodicals<br>1 (*never*) to 7 (*always*) |

# Appendix D

**Table D.1.** Additional demographic statistics of participants (*N = 709*).

| Measures | Items | Frequency | Percent |
|---|---|---|---|
| Position | Teacher | 654 | 92.2 |
| | Director | 37 | 5.2 |
| | Principal | 18 | 2.5 |
| Years of sharing experience | <1 | 155 | 21.9 |
| | 1-3 | 232 | 32.7 |
| | 4-5 | 103 | 14.5 |
| | 6-10 | 147 | 20.7 |
| | >10 | 72 | 10.2 |
| School type | Teaching site in village | 56 | 7.9 |
| | Primary school in village | 139 | 19.6 |
| | Primary school in town | 204 | 28.8 |
| | Secondary school in town | 148 | 20.9 |
| | Nine-year School in town | 162 | 22.8 |

**Table D.2.** Convergent validity and internal reliability.

| Constructs | Parameters of significant test | | Composite Reliability (CR) | Average of Variance Extracted (AVE) | Cronbach's α |
|---|---|---|---|---|---|
| | Factor Loading | Measurement Error | | | |
| INT | | | 0.824 | 0.541 | 0.822 |
| INT1 | 0.781*** | 0.021 | | | |
| INT2 | 0.678*** | 0.025 | | | |
| INT3 | 0.705*** | 0.024 | | | |
| INT4 | 0.772*** | 0.021 | | | |
| EXT | | | 0.792 | 0.559 | 0.791 |
| EXT1 | 0.703*** | 0.026 | | | |
| EXT2 | 0.791*** | 0.025 | | | |
| EXT3 | 0.747*** | 0.025 | | | |
| SE | | | 0.863 | 0.677 | 0.861 |
| SE1 | 0.806*** | 0.018 | | | |
| SE2 | 0.893*** | 0.016 | | | |
| SE3 | 0.765*** | 0.020 | | | |
| ATT | | | 0.863 | 0.678 | 0.861 |
| AT1 | 0.773*** | 0.019 | | | |
| AT2 | 0.843*** | 0.017 | | | |
| AT3 | 0.852*** | 0.017 | | | |
| SC | | | 0.878 | 0.645 | 0.876 |
| SC1 | 0.778*** | 0.018 | | | |
| SC2 | 0.884*** | 0.013 | | | |
| SC3 | 0.808*** | 0.017 | | | |
| SC4 | 0.734*** | 0.020 | | | |
| WP | | | 0.788 | 0.561 | 0.769 |
| WP1 | 0.649*** | 0.029 | | | |
| WP2 | 0.919*** | 0.028 | | | |
| WP3 | 0.645*** | 0.029 | | | |
| SIIS | | | 0.854 | 0.661 | 0.852 |
| SIIS1 | 0.833*** | 0.018 | | | |
| SIIS2 | 0.775*** | 0.020 | | | |
| SIIS3 | 0.829*** | 0.018 | | | |
| SIOS | | | 0.886 | 0.722 | 0.885 |

| | | | | | |
|---|---|---|---|---|---|
| SIOS1 | 0.878*** | 0.014 | | | |
| SIOS2 | 0.827*** | 0.016 | | | |
| SIOS3 | 0.843*** | 0.015 | | | |
| SBIS | | | 0.803 | 0.577 | 0.801 |
| SBIS1 | 0.790*** | 0.024 | | | |
| SBIS2 | 0.717*** | 0.025 | | | |
| SBIS3 | 0.769*** | 0.024 | | | |
| SBOS | | | 0.911 | 0.674 | 0.909 |
| SBOS1 | 0.775*** | 0.017 | | | |
| SBOS2 | 0.740*** | 0.019 | | | |
| SBOS3 | 0.884*** | 0.011 | | | |
| SBOS4 | 0.819*** | 0.014 | | | |
| SBOS5 | 0.877*** | 0.011 | | | |

***$p < 0.001$.

**Table D.3.** Path coefficients for within and outside school.

| Paths | Path coefficients for within school | Results for within school | Path coefficients for outside school | Results for outside school |
|---|---|---|---|---|
| INT → SE | 0.587*** | Yes | 0.583*** | Yes |
| INT → ATT | 0.790*** | Yes | 0.787*** | Yes |
| INT → SI | 0.078 | No | 0.216** | Yes |
| INT → SB | 0.274** | Yes | 0.318*** | Yes |
| EXT → SE | 0.029 | No | 0.030 | No |
| EXT → ATT | -0.172*** | Yes | -0.172*** | Yes |
| EXT → SI | -0.022 | No | -0.038 | No |
| EXT → SB | -0.104* | Yes | -0.092* | Yes |
| SE → SI | 0.433*** | Yes | 0.543*** | Yes |
| SE → SB | 0.325*** | Yes | 0.215*** | Yes |
| ATT → SI | 0.382*** | Yes | 0.047 | No |
| ATT → SB | -0.148 | No | -0.208** | Yes |
| SI → SB | 0.073 | No | 0.118* | Yes |
| SC → SB | 0.122 | No | 0.139* | Yes |
| WP → SB | 0.028 | No | 0.017 | No |

Note: ***$p < 0.001$, **$p < 0.01$, * $p < 0.05$.

**Table D.4.** Bias-corrected bootstrapped confident intervals of the indirect effects.

| Mediation path | *B* | SE | 95% CI for indirect effect | |
|---|---|---|---|---|
| (IV → MV→ DV) | | | Lower limit | Upper limit |
| *Within school* | | | | |
| INT → SI | 0.691 | 0.148 | 0.470 | 1.065 |
| Specific 1: INT → SE → SI | 0.315 | 0.065 | 0.216 | 0.475 |
| Specific 2: INT → ATT → SI | 0.375 | 0.128 | 0.163 | 0.673 |
| EXT → SI | -0.049 | 0.043 | -0.148 | 0.022 |
| Specific 1: EXT → SE → SI | 0.011 | 0.024 | -0.037 | 0.057 |
| Specific 2: EXT → ATT → SI | -0.060 | 0.027 | -0.131 | -0.018 |
| *Outside school* | | | | |
| INT → SI | 0.553 | 0.157 | 0.287 | 0.853 |
| Specific 1: INT → SE → SI | 0.496 | 0.093 | 0.350 | 0.721 |
| Specific 2: INT → ATT → SI | 0.057 | 0.166 | -0.362 | 0.260 |
| EXT → SE →SI | 0.010 | 0.044 | -0.089 | 0.087 |
| Specific 1: EXT → SE → SI | 0.019 | 0.037 | -0.057 | 0.088 |
| Specific 2: EXT → ATT → SI | -0.009 | 0.027 | -0.051 | 0.047 |

*Note. B* indicates the strength of the indirect effect.

## **Appendix E.** The remaining items for each variable

**INT**
1. Because this represents a meaningful choice to me.
2. Because this is an important goal to me.
3. Because I enjoy doing it.
4. Because it's fun.

**EXT**
1. Because that's something others (principals, colleagues, etc.) want me to do.
2. Because others (principals, colleagues, etc.) oblige me to do so.
3. Because that's what others (principals, colleagues, etc.) expect me to do.

**SE**
1. It's easy for me to share digital educational resources.
2. I have enough skills to share digital educational resources.
3. I can help others if they have digital educational resources sharing-related questions.

**ATT**
1. If I share my digital educational resources, I feel enjoyable.
2. If I share my digital educational resources, I feel valuable.
3. If I share my digital educational resources, I feel beneficial.

**SC**
1. In our school, there are sufficient supports for sharing digital educational resources.
2. In our school, teachers share conceptions and ideas about their educational vision.
3. In our school, teachers share knowledge about developments in education.
4. In our school, teachers share knowledge and experiences about changes they implemented in their lesson practices.

**WP**
1. Do you have to work very fast?
2. Do you have too much work to do?
3. Do you need to work extra hard to get your work done?

**SIIS**
1. How big is the chance for you to share digital educational resources in school
2. Do you plan to share digital educational resources in school?
3. Do you intend to share digital educational resources in school?

**SIOS**
1. How big is the chance for you to share digital educational resources outside school
2. Do you plan to share digital educational resources outside school?
3. Do you intend to share digital educational resources outside school?

**SBIS**
1. Digital text
2. Micro lecture/ micro video
3. Subject software and tools

**SBOS**

1. Electronic lesson plans
2. Exercises
3. Digital text
4. Micro lecture/ micro video
5. Subject software and tools

## **Appendix F.** References of studies included in the present meta-analysis

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# **Appendix G.** Overview of studies included in the meta-analysis

| Study | Region | Community type | SES | Education level | Learning environment | School subjects | Mobile technologies used in intervention group | Student-to-hardware ratio in intervention group | Teaching method in intervention group | Duration of the intervention | Research design | Instructor equivalence | Learning topic/ content equivalence | Software/ tool equivalence | Degree of technology use in control group | Procedure of effect size extraction |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Al-Balushi, Al-Musawi, Ambusaidi, and Al-Hajri (2017) | Oman | Not reported | Not low | Secondary school | Formal setting | Science | Handheld devices with multiple functions | Own | Mixed | > 4 weeks | Quasi-experimental | Different | Same | Same | Pen-and-paper | Calculated from exact descriptive |
| Alcoholado,-Diaz,Tagle, Nussbaum, and Infante (2016) | Chile | Not reported | Low | Primary school | Formal setting | Mathematics | Handheld devices with multiple functions | [a] Shared: comparison 1; own: comparison 2 | Computer-assisted testing/ assessment | > 4 weeks | Quasi-experimental | Same | Same | Same | Pen-and-paper | Calculated from exact descriptive |
| Alfadil (2020) | Saudi Arabia | Not reported | Not low | Secondary school | Formal setting | Language arts | Handheld devices with multiple functions | Shared | Game-based learning | 1 day-4 weeks | Quasi-experimental | Same | Same | Not reported | Pen-and-paper | Calculated from exact descriptive |
| Cavus and Ibrahim (2017) | Cyprus | Not reported | Not low | Secondary school | Unrestricted | Language arts | Handheld devices with multiple functions | Own | Self-directed learning | 1 day-4 weeks | Experimental | Not reported | Same | Same | Pen-and-paper | Calculated from exact descriptive |
| Çetinkaya and Sütçü (2018) | Turkey | Not reported | Not low | Secondary school | Unrestricted | Language arts | Handheld devices with multiple functions | Own | Self-directed learning | > 4 weeks | Quasi-experimental | Same | Same | Different | Not reported | Calculated from exact descriptive |
| Chang et al. (2020) | Taiwan | Not reported | Not low | Secondary school | Formal setting | Science | Handheld devices with multiple functions | Shared | Mixed | < 1 day | Quasi-experimental | Same | Same | Different | Traditional technology | Calculated from exact descriptive |
| Chang and Hwang (2018) | Taiwan | Not reported | Not low | Primary school | Formal setting | Science | Handheld devices with multiple functions | Not reported | Inquiry-oriented learning | 1 day-4 weeks | Quasi-experimental | Same | Same | Not reported | Pen-and-paper | Calculated from exact descriptive |
| Chien, Tsai, Chen, Chang, and Chen (2015) | Taiwan | Urban | Not low | Secondary school | Formal setting | Science | Handheld devices with one specific function | Shared | Inquiry-oriented learning | < 1 day | Experimental | Different | Same | Same | Traditional technology | Calculated from inferential statistics |
| Chu (2014) | Taiwan | Not reported | Not low | Primary school | Unrestricted | Social studies | Handheld devices with one specific function | Not reported | Computer-assisted testing/ assessment | < 1 day | Experimental | Same | Same | Same | Pen-and-paper | Calculated from exact descriptive |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Danaei, Jamali, Mansourian, and Rastegarpour (2020) | Iran | Not reported | Not low | Primary school | Informal setting | Language arts | Handheld devices with multiple functions | Own | Self-directed learning | Not reported | Quasi-experimental | Not reported | Same | Same | Pen-and-paper | Calculated from inferential statistics |
| del Olmo-Muñoz, Cózar-Gutiérrez, and González-Calero (2020) | Spain | Not reported | Not low | Primary school | Formal setting | Professional subjects | Handheld devices with multiple functions | Own | Inquiry-oriented learning | < 1 day | Quasi-experimental | Different | Different | Different | Not reported | Calculated from exact descriptive |
| Edwards, Rule, and Boody (2017) | USA | Not urban | Not low | Secondary school | Formal setting | Mathematics | Handheld devices with multiple functions | Own | Lectures | Not reported | Quasi-experimental | Same | Same | Same | Pen-and-paper | Calculated from inferential statistics |
| Erbas and Demirer (2019) | Turkey | Not reported | Not low | Secondary school | Formal setting | Science | Handheld devices with multiple functions | Not reported | Inquiry-oriented learning | > 4 weeks | Quasi-experimental | Same | Same | Different | Pen-and-paper | Calculated from exact descriptive |
| Fidan & Tuncel (2019) | Turkey | Not reported | Not low | Secondary school | Formal setting | Science | Handheld devices with multiple functions | Own | Inquiry-oriented learning | > 4 weeks | Quasi-experimental | Same | Same | [a] Same: comparison 1; Different: comparison 2 | Traditional technology | Calculated from exact descriptive |
| Furió, Juan, Seguí, and Vivó (2015) | Spain | Not reported | Not low | Primary school | Formal setting | Social studies | Handheld devices with multiple functions | Own | Game-based learning | Not reported | Experimental | Not reported | Same | Not reported | Not reported | Calculated from exact descriptive |
| Giasiranis and Sofos (2017 | Greece | Not reported | Not low | Secondary school | Formal setting | Professional subjects | Handheld devices with multiple functions | Not reported | Inquiry-oriented learning | < 1 day | Quasi-experimental | Not reported | Same | Same | Traditional technology | Calculated from exact descriptive |
| Huang, Su, Yang, and Liou (2017) | Taiwan | Not reported | Not low | Primary school | Formal setting | Mathematics | Handheld devices with one specific function | Own | [a] Inquiry-oriented learning: comparison 1; Lectures: comparison 2 | 1 day-4 weeks | Quasi-experimental | Different | Same | Same | Pen-and-paper | Calculated from exact descriptive |
| Huang, Yang, Chiang, and Su (2016) | Taiwan | Not reported | Not low | Primary school | Informal setting | Language arts | Handheld devices with multiple functions | Not reported | Self-directed learning | < 1 day | Quasi-experimental | Same | Different | Different | Pen-and-paper | Calculated from exact descriptive |
| Huang, Chen, and Hsu (2019) | Taiwan | Not reported | Not low | Primary school | Informal setting | Social studies | Handheld devices with multiple functions | Own | Inquiry-oriented learning | < 1 day | Quasi-experimental | Different | Same | Same | Pen-and-paper | Calculated from inferential statistics |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Huang and Lin (2017) | Taiwan | Not reported | Not low | Primary school | Informal setting | Science | Handheld devices with multiple functions | Not reported | Inquiry-oriented learning | < 1 day | Experimental | Same | Same | Different | Pen-and-paper | Calculated from exact descriptive |
| Huang, Shadiev, Sun, Hwang, and Liu (2017) | Taiwan | Not reported | Not low | Secondary school | Formal setting | Language arts | Handheld devices with multiple functions | Own | Inquiry-oriented learning | > 4 weeks | Quasi-experimental | Same | Same | Same | Pen-and-paper | Calculated from exact descriptive |
| Hung, Xu, and Lin (2020) | Mainland China | Urban | Not low | Primary school | Formal setting | Science | Not reported | Own | Inquiry-oriented learning | < 1 day | Quasi-experimental | Different | Same | Same | Traditional technology | Calculated from exact descriptive |
| Hung and Young (2015) | Taiwan | Not reported | Not low | Primary school | Formal setting | Language arts | Handheld devices with multiple functions | Own | Inquiry-oriented learning | < 1 day | Quasi-experimental | Not reported | Same | Same | Pen-and-paper | Calculated from exact descriptive |
| Hwang, Zhao, Shadiev, Lin, Shih, and Chen (2020) | Taiwan | Not reported | Not low | Primary school | Informal setting | Social studies | Handheld devices with multiple functions | Not reported | Inquiry-oriented learning | > 4 weeks | Quasi-experimental | Same | Same | Same | Pen-and-paper | Calculated from exact descriptive |
| Jere-Folotiya et al. (2014) | Zambian | Not reported | Not low | Primary school | Formal setting | Language arts | Handheld devices with multiple functions | Not reported | Game-based learning | 1 day-4 weeks | Quasi-experimental | Different | Different | Different | Not reported | Calculated from exact descriptive |
| Jong, Chan, Hue, and Tam (2018) Sample 1 | Hongkong | Not reported | Not low | Secondary school | Informal setting | Social studies | Handheld devices with multiple functions | Not reported | Mixed | < 1 day | Quasi-experimental | Different | Same | Same | Pen-and-paper | Calculated from exact descriptive |
| Jong, Chan, Hue, and Tam (2018) Sample 2 | Hongkong | Not reported | Not low | Secondary school | Informal setting | Social studies | Handheld devices with multiple functions | Not reported | Mixed | < 1 day | Quasi-experimental | Different | Same | Same | Pen-and-paper | Calculated from exact descriptive |
| Jong, Chan, Hue, and Tam (2018) Sample 3 | Hongkong | Not reported | Not low | Secondary school | Informal setting | Social studies | Handheld devices with multiple functions | Not reported | Mixed | < 1 day | Quasi-experimental | Different | Same | Same | Pen-and-paper | Calculated from exact descriptive |
| Joo-Nagata, Abad, Giner, & García-Peñalvo (2017) | Chile | Urban | Not low | Primary school | Informal setting | Social studies | Handheld devices with multiple functions | Not reported | Computer-assisted testing/assessment | < 1 day | Quasi-experimental | Not reported | Same | Same | Traditional technology | [c] Calculated from exact descriptive/ Calculated from inferential statistics |
| Khan, Hwang, Azeem Abbas, and Rehman (2019) Sample 1 | Pakistan | Not urban | Not low | Primary school | Formal setting | Language arts | Handheld devices with multiple functions | Own | Game-based learning | 1 day-4 weeks | Quasi-experimental | Different | Same | Same | Pen-and-paper | Calculated from exact descriptive |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Khan, Hwang, Azeem Abbas, and Rehman (2019) Sample 2 | Pakistan | Not urban | Not low | Primary school | Formal setting | Language arts | Handheld devices with multiple functions | Own | Game-based learning | 1 day-4 weeks | Quasi-experimental | Different | Same | Same | Pen-and-paper | Calculated from exact descriptive |
| Ku, Huang, and Hus (2015) | Taiwan | Not reported | Not low | Primary school | Informal setting | Social studies | Handheld devices with one specific function | Not reported | Game-based learning | Not reported | Quasi-experimental | Same | Same | Not reported | Traditional technology | Calculated from exact descriptive |
| Lai, Chen, and Lee (2019) | Taiwan | Not reported | Not low | Primary school | Formal setting | Science | Handheld devices with multiple functions | Own | Mixed | 1 day-4 weeks | Quasi-experimental | Same | Same | Same | Traditional technology | Calculated from exact descriptive |
| Lee, Hao, Lee, Sim, and Huang (2019) | Taiwan | Not urban | Low | Secondary school | Formal setting | Science | Handheld devices with one specific function | Own | Computer-assisted testing/assessment | > 4 weeks | Quasi-experimental | Same | Different | Different | Traditional technology | Calculated from exact descriptive |
| Lin (2014) | Taiwan | Not reported | Not low | Secondary school | Formal setting | Language arts | Handheld devices with multiple functions | Own | Inquiry-oriented learning | > 4 weeks | Quasi-experimental | Same | Same | Same | Traditional technology | Calculated from exact descriptive |
| Lin (2017) | Taiwan | Not reported | Not low | Secondary school | Formal setting | Language arts | Handheld devices with multiple functions | Own | Inquiry-oriented learning | 1 day-4 weeks | Quasi-experimental | Different | Same | Same | Pen-and-paper | Calculated from exact descriptive |
| Nikou and Economides (2018) | Europe | Not reported | Not low | Secondary school | Informal setting | Science | Mixed | Own | Computer-assisted testing/assessment | > 4 weeks | Experimental | Same | Same | Same | Pen-and-paper | Calculated from exact descriptive |
| Outhwaite, Gulliford, and Pitchford (2017) Study 1 | UK | Not reported | Low | Primary school | Formal setting | Mathematics | Handheld devices with multiple functions | Own | Not reported | > 4 weeks | Quasi-experimental | Different | Not reported | Not reported | Not reported | Calculated from inferential statistics |
| Outhwaite, Gulliford, and Pitchford (2017) Study 4 | Uk | Not reported | Not low | Primary school | Formal setting | Mathematics | Handheld devices with multiple functions | Own | Not reported | > 4 weeks | Quasi-experimental | Same | Not reported | Not reported | Traditional technology | Calculated from exact descriptive |
| Passig, Tzuriel, and Eshel-Kedmi (2016) | Israel | Urban | Not low | Primary school | Formal setting | Mathematics | Handheld devices with multiple functions | Own | Computer-assisted testing/assessment | < 1 day | Experimental | Same | Same | Not reported | Pen-and-paper | Calculated from exact descriptive |
| Purba, Hwang, Pao, and Ma (2019) | Taiwan | Not reported | Not low | Secondary school | Unrestricted | Science | Handheld devices with multiple functions | Not reported | Inquiry-oriented learning | 1 day-4 weeks | Quasi-experimental | Same | Same | Same | Pen-and-paper | Calculated from exact descriptive |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quintas, Bustamante, Pradas, and Castellar (2020) | Spain | Urban | Not low | Primary school | Formal setting | Science | Handheld devices with multiple functions | Own | Game-based learning | 1 day-4 weeks | Quasi-experimental | Same | Same | Different | Pen-and-paper | Calculated from exact descriptive |
| Ruiz-Ariza, Casuso, Suarez-Manzano, and Martínez-López (2018) | Spain | Not reported | Not low | Secondary school | Informal setting | Not reported | Handheld devices with multiple functions | Own | Game-based learning | > 4 weeks | Experimental | Not reported | Different | Different | Not reported | [b] Calculated from exact descriptive/ Calculated from inferential statistics |
| Sahin and Yilmaz (2020) | Turkey | Not reported | Not low | Secondary school | Formal setting | Science | Not reported | Not reported | Lectures | 1 day-4 weeks | Quasi-experimental | Different | Same | Different | Pen-and-paper | Calculated from exact descriptive |
| Shadiev, Hwang, Huang, and Liu. (2015) | Taiwan | Not reported | Not low | Secondary school | Formal setting | Language arts | Handheld devices with multiple functions | Not reported | Self-directed learning | > 4 weeks | Quasi-experimental | Not reported | Same | Same | Pen-and-paper | Calculated from exact descriptive |
| Shadiev, Hwang, and Liu (2018) | Taiwan | Not reported | Not low | Secondary school | Formal setting | Language arts | Handheld devices with multiple functions | Not reported | Self-directed learning | 1 day-4 weeks | Quasi-experimental | Same | Same | Same | Pen-and-paper | Calculated from exact descriptive |
| Stanojević and Ranđelović (2018) | Serbia | Not reported | Not low | Secondary school | Formal setting | Professional subjects | Handheld devices with multiple functions | Own | Computer-assisted testing/ assessment | 1 day-4 weeks | Quasi-experimental | Same | Same | Same | Pen-and-paper | Calculated from exact descriptive |
| Su and Cheng (2015) | Taiwan | Not reported | Not low | Primary school | Informal setting | Science | Handheld devices with multiple functions | Own | [a] Mixed: comparison 1; Inquiry-oriented learning: comparison 2 | 1 day-4 weeks | Quasi-experimental | Same | Not reported | Not reported | Pen-and-paper | Calculated from exact descriptive |
| Sung, Hwang, Lin, and Hong (2017) | Taiwan | Urban | Not low | Primary school | Formal setting | Language arts | Handheld devices with multiple functions | Not reported | Game-based learning | < 1 day | Quasi-experimental | Not reported | Same | Not reported | Traditional technology | Calculated from exact descriptive |
| Vanbecelaere, Van den Berghe, Cornillie, Sasanguie, Reynvoet, and Depaepe (2020) | Belgium | Not reported | Not low | Primary school | Formal setting | [b] Language arts/ Mathematics | Handheld devices with multiple functions | Own | Game-based learning | > 4 weeks | Quasi-experimental | Not reported | Same | Same | Pen-and-paper | Calculated from exact descriptive |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volk, Cotič, Zajc, and Starcic (2017) | Slovenian | Not reported | Not low | Primary school | Formal setting | Mathematics | Handheld devices with multiple functions | Own | Mixed | > 4 weeks | Quasi-experimental | Different | Same | Same | Pen-and-paper | Calculated from exact descriptive |
| Walczak and Taylor (2018) | USA | Not urban | Low | Primary school | Formal setting | Social studies | Handheld devices with multiple functions | Shared | Mixed | 1 day-4 weeks | Experimental | Different | Same | Different | Pen-and-paper | Calculated from inferential statistics |
| Wang (2016) | Taiwan | Not reported | Not low | Secondary school | Informal setting | Language arts | Handheld devices with multiple functions | Own | Self-directed learning | 1 day-4 weeks | Quasi-experimental | Same | Same | Same | Pen-and-paper | Calculated from exact descriptive |
| Wang (2017a) | Taiwan | Urban | Not low | Secondary school | Unrestricted | Language arts | Handheld devices with multiple functions | Own | Self-directed learning | 1 day-4 weeks | Quasi-experimental | Not reported | Same | Same | Pen-and-paper | Calculated from exact descriptive |
| Wang (2017b) | Taiwan | Not reported | Not low | Secondary school | Formal setting | Language arts | Handheld devices with multiple functions | Own | Computer-assisted testing/assessment | 1 day-4 weeks | Quasi-experimental | Same | Not reported | Not reported | Pen-and-paper | Calculated from inferential statistics |
| Wollscheid, Sjaastad, Tømte, and Løver (2016) | Oslo | Not urban | Not low | Primary school | Formal setting | Language arts | Handheld devices with multiple functions | Own | Not reported | > 4 weeks | Quasi-experimental | Different | Not reported | Not reported | Pen-and-paper | Calculated from exact descriptive |
| Yallihep and Kutlu (2020) | Turkey | Not reported | Not low | Primary school | Formal setting | Professional subjects | Handheld devices with multiple functions | Not reported | Game-based learning | 1 day-4 weeks | Quasi-experimental | Same | Same | Different | Not reported | Calculated from exact descriptive |
| Zhang, Sung, Hou, and Chang (2014) sample 1 | Taiwan | Not reported | Not low | Primary school | Formal setting | Science | Handheld devices with multiple functions | Not reported | Inquiry-oriented learning | < 1 day | Quasi-experimental | Different | Same | Same | Pen-and-paper | Calculated from exact descriptive |
| Zhang, Sung, Hou, and Chang (2014) Sample 2 | Taiwan | Not reported | Not low | Primary school | Informal setting | Science | Handheld devices with multiple functions | Not reported | Inquiry-oriented learning | < 1 day | Quasi-experimental | Different | Same | Same | Pen-and-paper | [c] Calculated from exact descriptive/ Calculated from inferential statistics |
| Zheng, Warschauer, Hwang, and Collins (2014) | USA | Urban | Low | Primary school | Unrestricted | Science | Handheld devices with multiple functions | Own | Inquiry-oriented learning | > 4 weeks | Quasi-experimental | Different | Not reported | Not reported | Not reported | Calculated from inferential statistics |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zhu and Urhahne (2018) | Germany | Not reported | Not low | Secondary school | Formal setting | Mathematics | Handheld devices with multiple functions | Own | Computer-assisted testing/ assessment | > 4 weeks | Quasi-experimental | Different | Same | Not reported | Not reported | Calculated from exact descriptive |

[a] variables were different in the comparison groups for the same outcome variable.
[b] both variables were presented in one comparison group for the same outcome variable.
[c] both variables were presented in one comparison group for the different outcome variables

## **Appendix H.** Moderator analyses for affective and behavioral outcome variables

**Table H.1.** Moderator analyses and weighted mean effect sizes for affective outcome variables.

| Moderator category | Moderator variables | N | *g* | SE | 95% CI | $Q_B$ | *p* |
|---|---|---|---|---|---|---|---|
| **Teaching context** | **Education level** | | | | | | |
| | Primary school | 14 | 0.449 | 0.165 | [0.126, 0.773] | 0.523 | 0.470 |
| | Secondary school | 10 | 0.613 | 0.154 | [0.311, 0.915] | | |
| | **Learning environment** | | | | | | |
| | Formal settings | 18 | 0.548 | 0.156 | [0.243, 0.854] | 0.075 | 0.784 |
| | Informal settings | 5 | 0.483 | 0.177 | [0.136, 0.831] | | |
| | School subjects | | | | | | |
| | Language arts | 5 | 0.459 | 0.166 | [0.133, 0.785] | 1.809 | 0.179 |
| | Science | 10 | 0.846 | 0.234 | [0.386, 1.305] | | |
| **Learning process** | **Teaching method** | | | | | | |
| | Inquiry-oriented learning | 10 | 0.729 | 0.238 | [0.262, 1.196] | 3.949 | 0.052 |
| | Game-based learning | 6 | 0.216 | 0.114 | [-0.007, 0.439] | | |
| | **Duration of the intervention** | | | | | | |
| | < 1 day | 7 | 0.370 | 0.169 | [0.038, 0.702] | 0.636 | 0.728 |
| | 1 day-4 weeks | 8 | 0.612 | 0.302 | [0.020, 1.204] | | |
| | > 4 weeks | 8 | 0.518 | 0.181 | [0.163, 0.872] | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Study quality** | **Research design** | | | | | | |
| | Quasi-experimental | 20 | 0.484 | 0.139 | [0.212, 0.757] | 0.410 | 0.522 |
| | Experimental | 4 | 0.645 | 0.208 | [0.236, 1.053] | | |
| | **Instructor equivalence** | | | | | | |
| | Same | 12 | 0.767 | 0.194 | [0.386, 1.148] | 1.377 | 0.241 |
| | Different | 4 | 0.300 | 0.347 | [-0.380, 0.980] | | |
| | **Learning topic/ content equivalence** | | | | | | |
| | Same | 20 | 0.590 | 0.141 | [0.314, 0.866] | 5.713 | 0.017 |
| | Different | 4 | 0.169 | 0.106 | [-0.039, 0.377] | | |
| | **Software/ tool equivalence** | | | | | | |
| | Same | 11 | 0.342 | 0.128 | [0.091, 0.594] | 0.562 | 0.454 |
| | Different | 10 | 0.502 | 0.170 | [0.170, 0.834] | | |
| | **Degree of technology use in the control group** | | | | | | |
| | Pen-and-paper | 12 | 0.498 | 0.198 | [0.110, 0.886] | 0.254 | 0.614 |
| | Traditional technology | 8 | 0.631 | 0.175 | [0.289, 0.973] | | |

**Table H.2.** Moderator analyses and weighted mean effect sizes for behavioral outcome variables.

| Moderator category | Moderator variables | N | g | SE | 95% CI | $Q_B$ | p |
|---|---|---|---|---|---|---|---|
| **Teaching context** | **Education level** | | | | | | |
| | Primary school | 10 | 0.610 | 0.165 | [0.286, 0.934] | 0.298 | 0.585 |
| | Secondary school | 4 | 0.334 | 0.479 | [-0.605, 1.272] | | |
| | School subjects | | | | | | |
| | Language arts | 4 | 0.555 | 0.299 | [-0.031, 1.141] | 0.174 | 0.677 |
| | Science | 7 | 0.707 | 0.211 | [0.294, 1.120] | | |
| **Learning process** | **Duration of the intervention** | | | | | | |
| | < 1 day | 6 | 0.581 | 0.275 | [0.042, 1.119] | 0.021 | 0.885 |
| | 1 day-4 weeks | 6 | 0.628 | 0.179 | [0.278, 0.978] | | |
| **Study quality** | **Instructor equivalence** | | | | | | |
| | Same | 7 | 0.574 | 0.199 | [0.184, 0.964] | 0.001 | 0.979 |
| | Different | 5 | 0.563 | 0.367 | [-0.156, 1.282] | | |
| | **Software/ tool equivalence** | | | | | | |
| | Same | 8 | 0.787 | 0.176 | [0.442, 1.132] | 5.423 | 0.020 |
| | Different | 5 | 0.070 | 0.253 | [-0.426, 0.565] | | |

## **Appendix I.** Overview of the measurements and their constituting items

Items marked with an asterisk indicate items included in the multilevel analysis.

*Teacher beliefs*

*SN1: In the smart classroom, students can get the chance to talk to each other.
*SN2: In the smart classroom, students can ask each other to explain their ideas.
SN3: In the smart classroom, students can ask each other to explain their ideas.
*SN4: In the smart classroom, students can discuss with each other how to conduct investigations.
*SN5: In the smart classroom, students can discuss their ideas with each other.
*IL1: In the smart classroom, students can find out answers to questions by investigation.
*IL2: In the smart classroom, students can carry out investigations to test their own ideas.
*IL3: In the smart classroom, students can conduct follow-up investigations to answer their new questions.
*IL4: In the smart classroom, students can design their own ways of investigating problems.
*IL5: In the smart classroom, students can approach the problem from more than one perspective.
*RT1: In the smart classroom, students can think deeply about how they learn.
*RT2: In the smart classroom, students can think deeply about their own ideas.
*RT3: In the smart classroom, students can think deeply about new ideas.
*RT4: In the smart classroom, students can think deeply about how to become better learners.
*RT5: In the smart classroom, students can think deeply about their own understanding.
*FD1: In the smart classroom, students can have enough workspaces to use digital devices and learning resources.
*FD2: In the smart classroom, students can have an atmosphere which is comfortable to be in.
*FD3: In the smart classroom, students can have flexible furniture arrangements for multiple learning purposes.
*FD4: In the smart classroom, students can have visual displays that support teacher and student interactions.
*FD5: In the smart classroom, students can have enough space for multiple small group discussions.
*CN1: In the smart classroom, I feel like the students and I care about each other.
*CN2: In the smart classroom, I feel connected to the students in the class.
*CN3: In the smart classroom, I feel a spirit of community.
*CN4: In the smart classroom, I feel that this class is like a family.

*CN5: In the smart classroom, I feel a sense of trust toward others.
*EU1: The smart classroom can provide strong and reliable wireless connectivity.
*EU2: The smart classroom can have user-friendly learning devices and software.
*EU3: The smart classroom can use learning devices and software that take only a short time to learn how to use.
*EU4: The smart classroom can have learning devices and software which are fun to use.
*EU5: The smart classroom can use technology which is easy to navigate.
*PU1: The smart classroom can benefit my teaching experience.
*PU2: The smart classroom can present information in meaningful ways.
*PU3: The smart classroom can improve students' abilities to communicate with others.
*PU4: The smart classroom enables opportunities for engagement and interaction
*PU5: The smart classroom enables technology that is useful in a wide range of ways.
*MS1: The smart classroom enables discussion on a learning topic through teacher and student perspectives.
*MS2: The smart classroom enables presentation of a learning topic by personal research, group discussion, and lecture.
*MS3: The smart classroom enables exploration of various information sources during learning.
*MS4: The smart classroom can share content from me and my students through digital devices.
*MS5: The smart classroom can provide a combination of face-to-face and digital instruction.
*Classroom process quality: Instructional quality*
SN1: In the smart classroom, students got the chance to talk to each other.
SN2: In the smart classroom, students asked each other to explain their ideas.
*SN3: In the smart classroom, students discussed with each other how to conduct investigations.
SN4: In the smart classroom, students discussed their ideas with each other.
IL1: In the smart classroom, students found out answers to questions by investigation.
*IL2: In the smart classroom, students carried out investigation to test their own ideas.
*IL3: In the smart classroom, students conducted follow-up investigation to answer their new questions.
IL4: In the smart classroom, students designed their own ways of investigating problems.
IL5: In the smart classroom, students approached the problem from more than one perspective.
RT1: In the smart classroom, students thought deeply about how they learn.
RT2: In the smart classroom, students thought deeply about their own ideas.

*RT3: In the smart classroom, students thought deeply about new ideas.
RT4: In the smart classroom, students thought deeply about how to become better learners.
RT5: In the smart classroom, students thought deeply about their own understanding.
*CN1: In the smart classroom, I felt like the students and teacher care about each other.
CN2: In the smart classroom, I felt connected to the teacher and students in the class.
*CN3: In the smart classroom, I felt a spirit of community.
*CN4: In the smart classroom, I felt that this class is like a family.
CN5: In the smart classroom, I felt a sense of trust toward others.
CM1: In the smart classroom, none of the students disturbed the lesson.
CM2: In the smart classroom, students were quiet when the teacher spoke.
CM3: In the smart classroom, everybody listened and students were quiet.
CM4: In the smart classroom, nobody interrupted with talking.
CM5: In the smart classroom, everybody followed the teacher.
*Classroom process quality: The use of technology*
DD1: Digital devices for the teacher and whole class (e.g., projection screen, interactive whiteboard, and touch screen television).
*DD2: Mobile devices for the teacher and individual student (e.g., laptop, tablet, and smart phone).
DR1: Multimedia courseware
*DR2: Multimedia material (text, pictures, animation, video, audio, etc.)
*DR3: Question bank/test papers
*DR4: Subject software and tools (Geometry, virtual lab, etc.)
DR5: Thematic page/website
DR6: E-textbook/ periodicals
*DR7: Course management software
*Student engagement*
*BE1: In the smart classroom, I listened carefully in class.
*BE2: In the smart classroom, I paid attention in class.
*BE3: In the smart classroom, the first time my teacher talked about a new topic, I listened very carefully.
*BE4: In the smart classroom, I asked questions.
CE1: In the smart classroom, when doing the assignment, I tried to relate what I was learning to what I already know.
CE2: In the smart classroom, while studying, I tried to connect what I was learning with my own experiences.
CE3: In the smart classroom, I tried to make all the different ideas fit together and made sense.
*EE1: I felt curious about what we were learning.
EE2: I felt interested about what we were learning.
EE3: I enjoyed the class.