

Interventions for School Engagement for Children Experiencing  
Educational Interruption due to COVID-19: A Scoping Review

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## Declaration

This dissertation contains no material which has been accepted for the award of any other degree or diploma in any University, and, to the best of my knowledge, contains no materials previously published except where due reference is made.

I give permission for the digital version of my dissertation to be made available on the web, via the University's institutional digital repository, the Library Search and also through web search engines, unless permission has been granted by the School to restrict access for a period of time.



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## Author Contribution Statement

**Alexandra Tabe:** Conceptualisation, Data Curation, Investigation, Methodology, Writing – draft preparation. [REDACTED]: Conceptualisation, Methodology, Supervision, Writing – review and editing. [REDACTED]: Conceptualisation, Methodology, Supervision, Writing – review and editing.

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# Interventions for School Engagement for Children Experiencing Educational Interruption due to COVID-19: A Scoping Review

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## Abstract

COVID-19 has resulted in an interruption to education for children around the world. A scoping review was conducted to capture the current interventions described in the literature. Following a database search and screening process, 16 articles were identified that met inclusion criteria. Through data extraction, four types of intervention were identified; Public Health Strategies, Education System Based Strategies, Psychosocial Strategies, and Pedagogical Strategies. A summary of each article was provided which included an overview of theoretical frameworks, key features, outcomes, and measures of engagement, as well as critical appraisal of research quality. Suggestions for future research and development of interventions are discussed.

Keywords: COVID-19, Education, Scoping Review, Interventions, School Engagement

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## **Interventions for School Engagement for Children Experiencing Educational Interruption due to COVID-19: A Scoping Review**

COVID-19 brought health into our everyday. To tackle the global public health crisis, prevention strategies were implemented by governments, businesses, and schools around the world, changing the way society functions. When it comes to the health and development of children, the pandemic has introduced new factors and barriers to consider. This scoping review identifies interventions that target school engagement for children who are experiencing educational interruption due to COVID-19.

Education is recognised as a building block of development for children, psychologically, socially, and physically (Fu & Underwood, 2015; OECD, 2020; Smith et al., 2007). Negative mental and physical health outcomes in adulthood can be associated with poor mental health in childhood, including suicide, risk taking, and lower quality of life (Meherali et al., 2021; Salmela-Aro et al., 2021; Smith et al., 2007). By equipping educators, mental health professionals, and parents/guardians with the tools to support students who are experiencing educational interruption due to global pandemics, physical illness, and mental health, we are supporting the positive development of children as they grow into adulthood (Fisher et al., 2021; Lebor, 2017; Mhlanga & Ramoroka, 2021; Wong & Liem, 2021).

Given the interruption caused by the COVID-19 pandemic in society, it is not hard to understand the impact that this ongoing cultural shift may have on children (Branje & Morris, 2021; Gallagher-Mackay et al., 2021; Maldonado & De Witte, 2021; Masters et al., 2020). The changes brought on by the pandemic have the potential to change the way children interact with the education system, their peers, and broader society (Harmey, 2021; Masters et al., 2020; McCoy et al., 2021; Rosenthal et al., 2021; Whitley et al., 2021). Other interruptions to education are physical or mental illness that require a child to have an absence from school, and there may also be other family or societal events that cause educational interruption. These

events, individually or combined, have the potential to have a long-term impact for children's education outcomes (Branje & Morris, 2021; Doyle, 2020; Gallagher-Mackay et al., 2021; Maldonado & De Witte, 2021). The aim of this review is to identify the current interventions described in the literature to support children returning to school after absences caused by the COVID-19 pandemic.

In the context of COVID, there are some identified reasons for educational interruption. This could include school closures due to lockdowns, individual students missing class due to contracting COVID or due to a household member contracting COVID, students missing class due to not having the materials or access to online learning where schools have had to adapt due to school closure and lockdowns, and various other impacts on a child's education and involvement with school due to the pandemic (Almulla, 2022; Anas Ratib et al., 2021; Rosenthal et al., 2021; Skinner et al., 2021; Whitely et al., 2021).

## **1.1 Definitions of Key Terms**

### ***1.1.1 School Engagement***

For this study, school engagement is defined as a student's direct involvement with schooling (Gourlay et al., 2021; Martins et al., 2021; Wong & Liem, 2021). This could be measured through a student's class attendance, participation in school activities, or academic performance. This review aims to explore any intervention that targets school engagement, and it is recognised that the type of intervention may alter the conceptualisation and measurement of school engagement.

### ***1.1.2 Educational Interruption***

The educational interruption being explored in this review is that caused by COVID-19. This could include school closure due to lockdowns, children missing school due to being COVID-19 positive or being in isolation due to being a close contact, inaccessibility to materials

or technology required to access remote or online learning, and many other impacts that COVID-19 may have on children's ability to engage in education. While there may also be impacts on caregivers, teachers, and other people that cause children to experience educational interruption, this review is focused on interventions that target school children specifically.

## **1.2 Purpose of Current Scoping Review**

There have been findings in this area that explore the effects of education interruption on education outcomes and mental health outcomes (Fisher et al., 2021; Fu & Underwood, 2015; Smith et al., 2007), however, this study aims to focus on the interventions themselves. The extensive research on outcomes of education interruption primes this study to explore interventions in the context of COVID-19 (Al-Taweel et al., 2020; Ariyo et al., 2022; Bacher-Hicks et al., 2021; Li et al., 2022; Martins et al., 2021; OECD, 2020). Similarly, there has been an influx of research exploring the impact of COVID-19 on education and mental health outcomes in various settings (Araya & Diaz, 2020; Bojović et al., 2020; Heidari et al., 2021; Hu et al., 2021; Khan et al., 2021; Krywult-Albańska & Albański, 2021; Maestrales et al., 2022; Sakaue et al., 2021). This scoping review aims to identify and analyse current interventions targeting school engagement for children experiencing educational interruption due to COVID-19. The hope is that the findings of this review will influence future research while providing recommendations for practice regarding current interventions, and benefit any interventions developed in the future.

Due to the recency of COVID-19, and the immense impact of restrictions and school closures, a scoping review is most appropriate to gain a preliminary understanding of interventions designed to engage children in education through a global health pandemic. The purpose of this review is to collate available knowledge and collect relevant data of interventions. The following objectives were developed to guide the collection and synthesis of results:

1. What features, components, and materials do the interventions utilise and how were these features, components and materials designed?
2. If interventions were implemented, what were the observations and outcomes and how was school engagement measured?
3. What theoretical frameworks were used to develop interventions and how were these applied in the delivery of interventions?
4. Do the interventions have applications in other contexts of educational interruptions?

## 2. Method

The process of designing and conducting this review followed the PRISMA guidelines for scoping reviews (Tricco et al., 2018). The review protocol was developed with the research team to determine the objectives of the review and to establish a strategy for conducting database searches. The current scoping review protocol was registered on Open Science Framework on 17 August 2022 (<https://osf.io/zkfm4>).

In order to be included in the review, articles had to be published after the start of the COVID-19 pandemic. This was determined to be from 31 December 2019, as the World Health Organization became aware of the first cases in China and began to respond on 31 December 2019 (WHO, 2020). The articles also had to focus on school children specifically aged between 4-18 years. Articles were included that discussed interventions designed for use for school children experiencing educational disruption caused specifically by COVID-19 and its related impacts, this could include interruption due to remote learning, lockdowns, school closure, access to education, contracting COVID-19, or other related reasons. The article could be discussing, evaluating, or outlining the intervention, which could be developed, designed, or implemented using any theoretical framework, and could be set in any country. Articles were excluded if the intervention was targeted for any population that was not school children, this meant that articles focusing on teachers, caregivers, or education providers as well as articles that focused on students in university or other higher education institutions were excluded.

The following databases were searched for literature that discuss interventions for school children experiencing educational interruption due to COVID-19: SCOPUS database and platform; ERIC and ProQuest via the ProQuest platform; PsycINFO, Medline, and Embase via the Ovid platform; and PubMed via the National Library of Medicine platform. The databases to be searched as well as the search strategy was developed in collaboration with an academic

health science librarian. The first search was conducted on 22 August 2022 (Table 1) and the most recent search was executed on 24 August 2022.

**Table 1**

*PyscINFO Search Strategy Executed on 22 August 2022*

Intervention (AND)	School Children (AND)	Engagement (AND)	COVID
(exp School Based Intervention OR exp Intervention)	(exp Elementary school students OR high school students OR junior high school students OR middle school students)	exp School Attendance	COVID-19.sh
OR	OR	OR	OR
(school based strateg* OR strateg* OR school policy OR school policies OR policy OR policies OR education* policy OR education* policies OR plan* OR school based approach* OR approach* OR school program* OR education program OR program* OR treatment* OR prevent* OR school based intervention* OR intervention* OR school service* OR service*).ti,ab	OR (school age children OR 5-18 years old OR child* OR teen* OR adolescen* OR student*).ti,ab	(school OR academic OR education* OR learner OR learning OR student*) adj4 (engag* OR learn* OR attend* OR perform* OR achieve* OR participat* OR absen* OR leave OR disengage* OR drop-out OR dropout).ti,ab	(COVID-19 OR covid OR long covid OR pandemic OR coronavirus OR covid 19).ti,ab

The results of the database searches were imported into the Covidence program ([www.covidence.org](http://www.covidence.org)) for screening. Covidence has an inbuilt feature for detecting duplicates which was utilised as search results were imported. An initial screen of titles and abstracts was conducted by the primary author and fifty were screened by a second independent reviewer, during this phase of screening there was an 100% agreement rate between reviewers. Following this, full text articles were screened for relevance to the objectives of the current review. A second independent reviewer also screened twenty full text articles to ensure consistency in the review process. There was an agreement rate of 80% between reviewers on screening of full text articles. Discrepancies in screening were resolved through discussion between the primary author and the second independent reviewer to refine results and ensure consistency in the screening process.

Once all screening was completed the included full text articles were reviewed and relevant data was extracted. The data items to be extracted were developed to address the objectives of the scoping review. The primary author completed this process using an Excel spreadsheet that was created to enable data extraction of relevant data from the included articles. This spreadsheet included the following items:

- Citation details (APA formatting)
- Country of origin
- Level of schooling (e.g., primary school, middle school, high school, secondary school, etc.)
- Theoretical framework implemented in intervention
- Type of intervention (e.g., biopsychosocial, psychological, digital, etc.)
- Features, components, and materials of interventions (e.g., number of sessions, assessment tools used, delivery modality, etc.)
- Any reported efficacy or outcomes of interventions
- School engagement outcomes measured
- Recommendations from authors regarding future application or research

As this scoping review is exploring interventions and their outcomes, the Mixed Methods Appraisal Tool (MMAT; Hong et al., 2018) was used to measure the quality of studies included in the review. This tool allows for consistent appraisal of quality across various research designs. Critical appraisal of included studies was completed by the primary author and reported in conjunction with data synthesis.

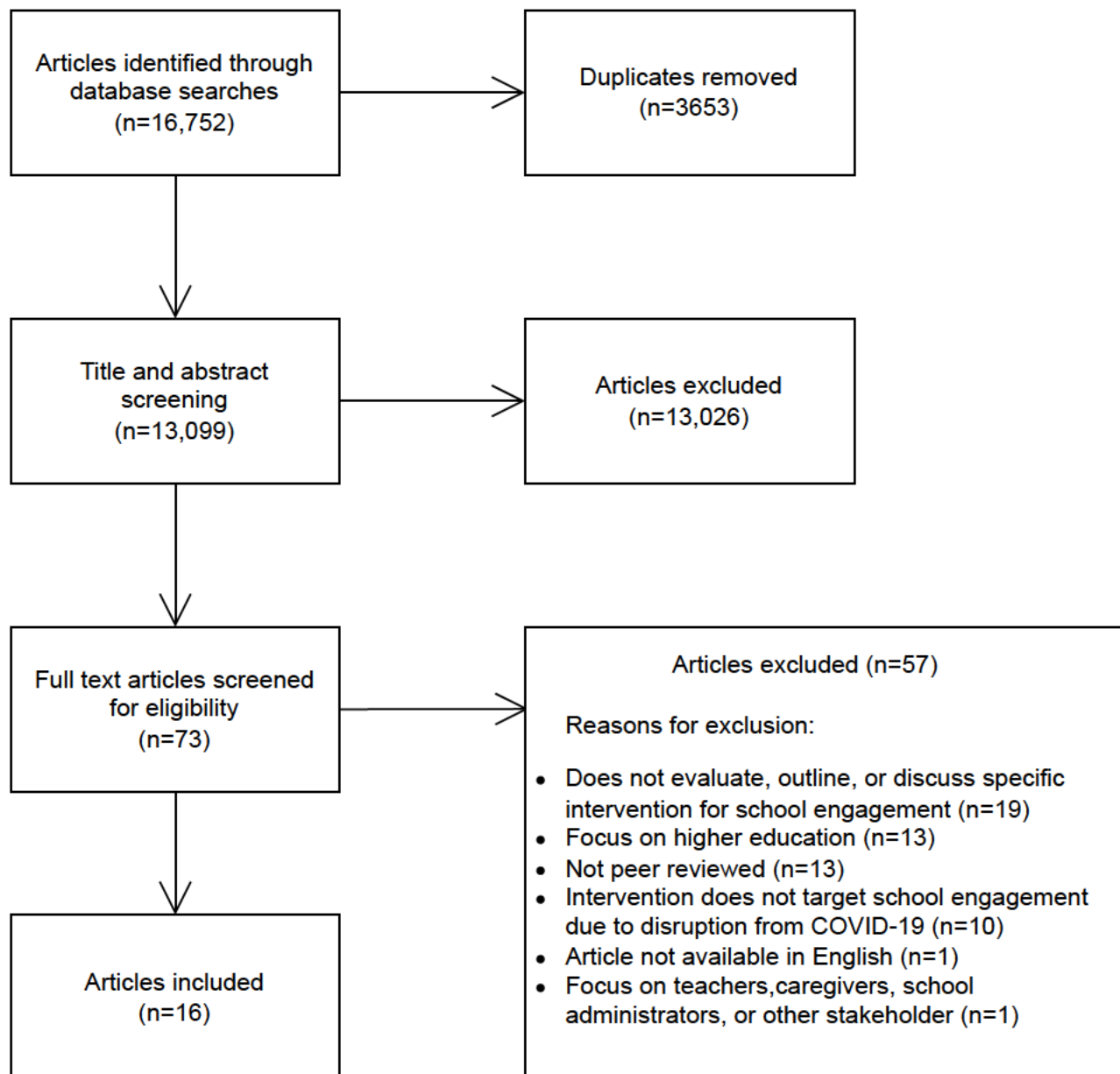
Articles were grouped by the type of intervention that was outlined, discussed, or evaluated. These categories were established to provide a distinction between types of intervention, and to compare findings of articles that focused on interventions of the same type. A summary of theoretical frameworks and features was provided, as well as the setting and context of each article. For articles that evaluated an intervention the efficacy and outcomes, as well as measures of school engagement, were reported. Findings were presented using tables and narrative summary.

### 3. Results

Selection of articles followed the inclusion and exclusion criteria set out in the scoping review protocol. A flow diagram (Figure 1) depicts the number of articles excluded at each stage of the screening process.

**Figure 1**

*Flow Diagram of Screening Process*



### **3.1 Types of Interventions**

While extracting data from the sixteen included articles, there were four distinct types of interventions that emerged. These were Public Health Strategies, Education System Based Strategies, Psychosocial Strategies, and Pedagogical Strategies, which included the subtypes of Digital Pedagogy and Radio Learning. The types of intervention were recorded during data extraction and were refined based on the primary profession delivering the intervention, as well as the method of delivery, framed by the theoretical framework used to design the intervention. The results of each type of intervention are presented below:

#### **3.1.1 Public Health Strategies**

While there were many articles that discussed public health strategies in school settings, these did not meet inclusion criteria, as the main goal or outcome was to reduce the transmission and number of cases of COVID-19. There was one article in which the reported goal of the intervention was to create a safe environment for students so that they could remain in school during the pandemic. Kwon, Kang, and Kim (2021) present a case study of one high school in Seoul, South Korea, that utilised public health strategies to keep students engaged in education through the pandemic.

The intervention involved the entire school community collaborating and contributing to ensure its success. The framework used to implement the intervention was the “Personal and Community Prevention Safety Belt Strategy”. School staff planned the rollout of the intervention, setting the goals and acquiring the needed health supplies. Students then participated in education about how to keep themselves and their peers and teachers safe while in the school environment. This was delivered via videos that were produced by health teachers. The “Personal Safety Belt” strategy included prevention strategies such as wearing masks, hand washing, cleaning desks, and maintaining two metres physical distance from others. The

“Community Safety Belt” was in line with government guidelines for prevention and management of COVID-19, it also included secluded observation rooms for any staff member or student that exhibited symptoms, use of thermometers upon entry into the school, and providing cleaning supplies, sufficient masks, and hand sanitiser for all students and staff.

The results of this intervention were presented in a narrative form, describing the implementation and response of the school community. The school that implemented this strategy only experienced one case of COVID in a teacher, the students of this teacher had to quarantine as close contacts, however, other students learning and attendance were not affected. It was found that the intervention allowed for a safe environment for students and staff to continue with face-to-face learning. It was reported that some students started a club focused on promoting health safety activities, such as supporting students to adhere to the disinfection guide and individual prevention strategies that the school implemented, monitoring the consumption of hand sanitiser, and looking at where hand sanitiser dispensers were placed and if this was optimal for use. It was also reported that this club worked with the school health committee to produce a 15-minute video on the prevention of “Corona-blue”. This was not elaborated on but further research into the use of this term, specifically in Korea, revealed that “Corona-blue” is used to describe a specific kind of depression due to the changes in everyday life caused by COVID-19 (Myung Suk, 2020).

Overall, it was reported that the intervention was embraced well by the school community and by students, which allowed for the school to remain open following interruption to schooling caused by COVID-19 related public health mandates for school closure. In this case study, engagement in schooling was framed through the ability of students to physically attend their school.

Although the authors did not give recommendations about future application or research, they did outline some issues with the intervention, specifically relating to sustainability. The

budget required to supply the resources was reported to be a concern in terms of how long it could be sustained in order to continue the intervention. There were some changes made during the intervention to try and reduce spending, the example given was adding alcohol to wet wipes as a cost-effective way to provide disinfection products.

**3.1.1.1 Critical Appraisal of Public Health Strategies.** Using the MMAT (Hong et al., 2018) there were some issues found with the data collection methods in the case study (see Appendix A for quality appraisal criteria for each included article). This was due to a lack of clarification on how the data was collected, whether this was through direct observation, reports from participants, or other sources, was not made clear. The authors report that all data is available upon request, but it is unclear if this would illuminate how data was collected. There were no other issues found in the quality appraisal of this case study.

### ***3.1.2 Education System Based Strategies***

Similar to Public Health Strategies, there were many articles that discussed how education systems and policymakers responded to the impact of COVID-19 on schools, however the focus was on the stakeholders or there was no specific intervention discussed. There was one article that explored how an Education System implemented strategies with the goal of engaging children in school through the COVID-19 pandemic.

Childs, Groom, and Mozley (2022) present a case study of an independent charter school district in Dallas, Texas, that explored how school leaders responded to the challenges of COVID-19 and utilised organisational strategies to promote student attendance. An independent charter school is a community funded school that runs independently from State school districts, the school district in this article services two campuses with students from grades K-12. The authors used the framework of organisational culture and commitment to

explore how the leaders of the education system employed existing resources and redirected them to target school attendance and engagement during disruption due to COVID-19.

Results of this intervention were collected from interviews with the leadership of the school district, these were analysed, and three main strategies were presented in a narrative summary with quotes and examples from the participants. The first strategy presented focused on communication, specifically to families, to ensure that up to date information was disseminated, and connection to the school was maintained. The second strategy was about technology integration, especially important during the time of online learning. This involved supplying appropriate technology and online platforms for teachers and students that would allow them to engage and enjoy school, rather than creating a barrier to accessing education. The third strategy was a strong focus on reopening campuses so that students could attend face to face. It was also noted that school leaders, teachers, and other staff made home visits to provide resources such as meals and other materials.

There were general comments throughout the article that suggest that the school district was successful in increasing attendance, but no specific data was provided. The following quote from one of the participants was the main data point that suggested efficacy of the intervention, “We know our families wanted their students in school, and while some were hesitant at first, by the end of the school year we had nearly 98% of our kids back to in-person instruction”. In this case study, school engagement was framed through attendance, additionally there was a focus on providing quality education, despite the limitations placed on the school district due to COVID-19 restrictions.

The authors recommended that future research should investigate how schools within different districts responded to the COVID-19 pandemic. Specifically, their plans to reopen schools, how concerns of academic achievement were addressed, and practices and policies that focused on attendance despite COVID-19 disruptions. The authors highlighted that it would

be especially important to focus on school districts that serve a majority of students from historically disenfranchised backgrounds. The authors conclude that these findings will impact leaders of school districts and the reforms and strategies that they implement moving forward.

**3.1.2.1 Critical Appraisal of Education System Based Strategies.** As described above, there was a lack of specific substantiating evidence to support the efficacy of the strategies that were used to increase student attendance (see Appendix A). However, the framework of organisational culture and commitment suggests that the efficacy of the strategies was related to the individual leaders of the school district and how they responded to the disruption of school due to COVID-19. Specifically, how the existing organisational culture, and the individual and group commitment to that culture, promoted an environment where the leaders developed and implemented the intervention. Using this interpretation, the findings are consistent with the qualitative interviews with the school district leadership.

### **3.1.3 Psychosocial Strategies**

There were four articles included that implemented psychosocial strategies in the interventions for student engagement following disruption due to COVID-19. These interventions had aspects of pedagogical strategies and digital learning strategies, however the theoretical frameworks used, as well as the outcome measured used, focused on promoting students psychological and social wellbeing in order to foster positive engagement in education. Of note is the article from Cunha et al (2021) that utilised radio and letters to deliver the intervention, however the goal of the intervention was to teach students concepts and strategies of self-regulation to enhance their engagement in education during school closures due to COVID-19. The citation details, target school level, theoretical framework, and key features of each article are presented below (Table 2).

**Table 2***Characteristics of Articles Included Utilising Psychosocial Strategies*

Citation Details, Country, and Level of Schooling	Theoretical Framework	Key Features
Chiu, T. K. F. (2022) Hong Kong Middle School Grade 8 and 9	Reeve's four dimensions of student engagement and Self- determination Theory (SDT) in the context of digital support	Teachers who delivered the intervention attended workshops for 6 weeks to ensure consistency. The model had three parts as follows:  Autonomy support: <ul style="list-style-type: none"> <li>• Digital resources in various formats</li> <li>• Encouraging students to use any digital format to complete tasks</li> <li>• Allowing students to study when and where they chose</li> </ul> Structure: <ul style="list-style-type: none"> <li>• Clear instructions from teachers for digital submissions</li> <li>• Support for technical problems students may encounter</li> <li>• Using multimedia learning principles in the design of digital materials</li> <li>• Giving competence-relevant multimedia feedback to students.</li> </ul> Involvement: <ul style="list-style-type: none"> <li>• Teachers should host interactive real time lessons</li> <li>• Small teacher/student support groups of no more than five people through instant messaging</li> <li>• Teach using emotionally designed materials and resources</li> <li>• Use visual aids in communications to avoid misunderstanding and promote positivity e.g., emojis in messages</li> </ul>
Cunha J., Silva C., Guimarães A., Sousa P., Vieira C., Lopes D., & Rosário P. (2021)  Portugal  Primary School  Grade 3 and 4	Zimmerman's Self- Regulated Learning (SRL) model	Activities designed to teach Planning, Execution, and Evaluation (PLEE) concepts of SRL using the book 'Yellow Trials and Tribulations'.  Delivery for 6 sessions via radio and 12 sessions via letters.

Minkos, M. L., & Gelbar, N. (2020)  United States  K-12	Social-emotional Learning and Wellbeing through Multitiered System of Support (MTSS)	<p>Multitiered system of support (MTSS) to address Social-Emotional Learning and academic skill and ability to engage in schooling.</p> <p>Tier 1 - Social Emotional Supports</p> <ul style="list-style-type: none"> <li>• Promoting physically and psychologically safe environments through class discussions</li> <li>• Establishing routines and behavioural expectations</li> <li>• Trauma informed practices</li> <li>• Avoiding exclusionary disciplinary practices</li> <li>• Teaching students mindfulness practices and self-regulation strategies</li> </ul> <p>Tier 2 – Targeted Practices</p> <ul style="list-style-type: none"> <li>• Small group interventions</li> <li>• Cognitive behavioural intervention for trauma in schools program (CBITS)</li> </ul> <p>Tier 3 – One-on-one Interventions</p> <ul style="list-style-type: none"> <li>• School psychologists and other relevant professionals</li> </ul>
Speight, R., & Kucharczyk, S. (2021)  United States  Special Education – No Specific Grade	Positive Behaviour Intervention and Supports (PBIS)	<p>Essential elements of PBIS in a virtual classroom environment:</p> <ul style="list-style-type: none"> <li>• Prepared for learning e.g., technology, teaching materials</li> <li>• Following routines and procedures</li> <li>• Demonstrating expected behaviours</li> <li>• Students are showing high levels of engagement</li> <li>• Students are rewarded for their engagement and positive behaviours</li> </ul>

**3.1.3.1 Efficacy, Outcomes, and Measures.** The articles from Minkos & Gelbar (2020) and Speight & Kucharczyk (2021) outlined and discussed interventions without conducting an evaluation of an intervention's efficacy. Both articles provide an evidence base for the proposed intervention and cite examples of where these interventions have been successful in improving school engagement before COVID-19.

The articles from Chiu (2022) and Cunha et al (2021) evaluate an intervention and provide information of how engagement was measured and the success of the intervention. In the article from Chiu (2022), pre and post intervention tests were conducted that measured

students behavioural, emotional, cognitive, and agentic engagement (Appendix B), and moderate effects that were statistically significant were reported that suggested that the supports designed around self-determination theory (perceived autonomy, competence, and relatedness) were predictors of the four dimensions of student engagement. Perceived relatedness was the strongest predictor for behavioural, emotional, and agentic engagement and perceived competence was the strongest predictor for cognitive engagement.

Cunha et al (2021) utilised interviews with children who participated to assess the outcomes of the intervention. It was reported that children were able to describe the Planning, Execution, and Evaluation concepts of self-determination theory in their own words. This was framed as the intervention being positive, as children were able to learn the concepts through the radio and letter modalities. While the authors reported that they didn't use any specific measures of engagement, they did include this as a recommendation for future research.

**3.1.3.2 Recommendations from Authors.** Based on findings and challenges for students facing education disruption, Chiu (2022) suggested that relatedness factors should be the focus of educators to support students in engaging in education. Chiu specifically discusses the needs of children of different ages, and that younger students may require more relatedness and involvement support, and that all students require increased autonomy support, especially during remote learning. Chiu provided some practical suggestions (Appendix C) to applying the model and recommended that schools establish emergency transition plans should online learning be required in potential future school disruptions due to societal or public health crises.

Cunha et al (2021) highlight the importance of offline modes of delivery for students who have limited access to technology. It was also suggested that future research should address the limitation of students who were unable to access education in any capacity during school closures.

Minkos & Gelbar (2020) suggest educators and schools examine and build upon existing support systems to address student needs based on their unique challenges. They also suggest that schools and their staff will need to be flexible in navigating current challenges associated with COVID-19 and that the support systems will develop resilience to cope with any potential future educational disruption.

Speight & Kucharczyk (2021) present an intervention that is being recommended for implementation, specifically in the context of special education.

**3.1.3.3 Critical Appraisal.** In the critical appraisal of the article from Chiu (2022), it was determined that the article presented a quantitative non-randomised study and there were no issues found with the methodological quality.

The study from Cunha et al (2021) did have limitations on data collection methods due to the delivery modality of radio and letters, as well as the remote locations of participants. This was also highlighted as the authors reported they did not use any specific measures for engagement within their data collection.

As the articles from Minkos & Gelbar (2020) and Speight & Kucharczyk (2021) did not evaluate an intervention, there was no quality appraisal performed using the MMAT. Both articles gave evidence-based approaches and suggested an implementation of strategies to address student engagement in the context of educational disruption due to COVID-19.

### **3.1.4 Pedagogical Strategies**

There were four articles included that implemented pedagogical strategies, the following section focuses on the articles that were not included in the subtype of Digital Learning or Radio Learning. These interventions utilised pedagogical frameworks and focused on techniques of teaching to improve student engagement in the context of education disruption due to COVID-

19. The citation details, target school level, theoretical framework, and key features of each article are presented below (Table 3).

**Table 3**

*Characteristics of Articles Included Utilising Pedagogical Strategies*

Citation Details, Country, and Level of Schooling	Theoretical Framework	Key Features
Edyburn, D. (2021) United States K-12	Own it, Learn it, Share it (OLSit) Model	<p>Own It phase:</p> <ul style="list-style-type: none"> <li>• Students set a learning goal</li> <li>• Students create a learning plan with assistance from a teacher</li> <li>• Guidance given in the form of suggested resources, insights, and ideas</li> </ul> <p>Learn It phase:</p> <ul style="list-style-type: none"> <li>• Student engages in learning activities based on learning plan</li> </ul> <p>Share It phase:</p> <ul style="list-style-type: none"> <li>• Student identifies an audience and a modality to share their learning</li> </ul>
Li, Y., Zhang, X., Dai, D. Y., & Hu, W. (2021) China Primary School	Thinking-Based Instruction Theory (TBIT)	<p>These are to be used by educators to design courses that implement TBIT and are therefore thought to promote engagement. The five principles:</p> <ol style="list-style-type: none"> <li>1. Stimulating interest and motivation</li> <li>2. Cognitive conflict</li> <li>3. Knowledge-construction</li> <li>4. Self-regulation and metacognition</li> <li>5. Application and transfer</li> </ol> <p>The six steps are based on the five principles and guide the curriculum design and instructional activities. The six steps are:</p> <ol style="list-style-type: none"> <li>1. Situation creation</li> <li>2. Questioning</li> <li>3. Independent inquiry</li> <li>4. Cooperation and communication</li> <li>5. Summary and reflection</li> <li>6. Application and transfer</li> </ol>

<p>Maestres, S., Dezendorf, M. R., Tang, X., Salmela- Aro, K., Bartz, K., Juuti, K., Lavonen, J., Krajcik, J., &amp; Schneider, B. (2022)</p> <p>United States and Finland</p> <p>High School Grades 10, 11, and 12</p>	<p>Crafting Engaging Science Environments (CESE)</p>	<p>Project based activities that include:</p> <ul style="list-style-type: none"> <li>• Frequent use of science and engineering practices</li> <li>• Class discussions</li> <li>• Working together to understand phenomena</li> <li>• Various modelling activities</li> <li>• Presenting their work</li> <li>• Conducting experiments at home</li> </ul>
<p>Opere, W. M. (2021)</p> <p>Kenya</p> <p>Secondary School</p>	<p>Target, Simulation, Authentication, Harmonisation (TSAH) Model, derived from aspects of Provocative Lecture Model, Simulation Learning Model, Mobile Learning Theory, Experimental Learning Theory</p>	<p>Lesson and course design should follow these steps:</p> <ol style="list-style-type: none"> <li>1. A lecture framework that is flexible in focusing on key areas of the targeted topic delivered through a guided presentation</li> <li>2. Virtual simulation that allows for significant interaction between students and teachers to enhance learning from (1)</li> <li>3. An experiment framework that is focused on the premise in (1) and (2) and can be conducted safely at home</li> <li>4. A student centred two-way system for feedback regarding activities at (3)</li> </ol>

**3.1.4.1 Efficacy, Outcomes, and Measures.** The articles from Edyburn (2021) and Opere (2021) outlined and discussed interventions without conducting an evaluation of an intervention's efficacy. Both articles draw from existing pedagogical models and theories that have previously been found to be effective in enhancing student engagement and the authors have suggested modifications to address the educational disruption due to COVID-19.

Li et al (2021) measured students experience and engagement in the course using the Course Experience Questionnaire, the Mayer Learning Experience Questionnaire, and the Online Learning Behaviour Questionnaire (more detail provided in Appendix C), they also had

informal interviews with teachers to understand their perspective on the student's engagement in their lessons. There was a statistically significant difference in students' completing Thinking-Based Instruction Theory courses measures of motivation and understanding compared to students completing standard national curriculum courses, however, there was no difference in students' interest or engagement. Teachers reported that students showed a high willingness to participate in the Thinking-Based Instruction Theory learning activities.

Maestrales et al (2022) reported the outcomes of the intervention using a logistic regression model, controlling for confounding factors, and found that learning activities from the intervention had a statistically significant predictive effect on students' reported engagement. It was also found that the frequency of activities correlated with academic engagement during remote learning. The researchers measured students' perceived interest, skill, and challenge in learning activities using student experience surveys, and combined these three aspects of learning to calculate engagement (Appendix D). Students also completed their feelings and experience during remote lessons in a diary format which was used to gauge their situational engagement.

**3.1.4.2 Recommendations from Authors.** Each articles authors suggest further research into the model presented in their respective papers, and how they might be developed further for online and remote learning due to education disruption caused by COVID-19 and potential future interruptions to schooling. More specifically, Edyburn (2021), suggests that there is an urgent need for further research into how to support students with under-developed self-regulation skills, as well as students who lack access to resources, such as technology. Edyburn also highlights current research into student centred remote learning and the impact of different learning activities, which could help to direct the implementation of the OLSit model.

The articles from Opere (2021) and Maestrales et al (2022) both focus on science education, and their recommendations similarly suggest that their models be utilised to encourage science learning during COVID-19. Both authors also raise concerns about students who may not have access to required resources for remote science education due to school closures.

**3.1.4.3 Critical Appraisal.** As the articles from Edyburn (2021) and Opere (2021) did not evaluate an intervention, there was no quality appraisal performed using the MMAT. However, the Edyburn article is much shorter than other included articles and has noticeably scarce explanation and discussion of the proposed model.

The article from Li et al (2021) had issues with complete data and accounting for confounding variables. It was reported that some responses were excluded as participants did not answer every question in the provided questionnaires, this potentially excluded valuable data from the questions that these participants did respond to. The second issue of accounting for confounding variables occurred in the interpretation of results. The authors reported that some methods of data collection had to be altered as students from one of the schools were 3-4 years younger, however, when interpreting results, the age difference and potential biases caused by the alternative data collection was not considered.

Maestrales et al (2022) reported some limitations in the consistency of the delivery of the intervention between the two countries. This was understandable, due to the differing COVID-19 requirements and the way schools had to adapt to remote learning. These limitations are accounted for and explored in the methods and results section of the article.

**3.1.4.4 Digital Pedagogy.** There were four articles included that implemented pedagogical strategies that were specifically designed using online learning and the integration of digital technology in interventions for student engagement during educational disruption due

to COVID-19. The citation details, target school level, theoretical framework, and key features of each article are presented below (Table 4).

**Table 4**

*Characteristics of Articles Included Utilising Digital Pedagogy Strategies*

Citation Details, Country, and Level of Schooling	Theoretical Framework	Key Features
Abouhashem, A., Abdou, R.M., Bhadra, J., Santhosh, M., Ahmad, Z., & Al- Thani, N.J. (2021)  Qatar  Middle and High School	Online Interactive Learning developed using various previous research findings	Virtual STEM topics designed and presented as follows: <ul style="list-style-type: none"> <li>• Designed by university mentors and delivered by undergraduate students</li> <li>• 1-hour daily lessons for 1 week for each course</li> <li>• Lesson structure: <ul style="list-style-type: none"> <li>• Introduction session</li> <li>• Scientific session</li> <li>• Concluding session</li> </ul> </li> <li>• Utilising the following digital teaching tools: <ul style="list-style-type: none"> <li>• Microsoft Teams</li> <li>• Microsoft PowerPoint</li> <li>• Videos</li> <li>• Online Games</li> <li>• Simulations</li> <li>• Puzzles</li> </ul> </li> </ul>
Foster, C., Burkhardt, H., & Schoenfeld, A. (2022)  United Kingdom  K-12	Teaching for Robust Understanding (TRU)	Student centred pedagogy using technology that stimulates thinking using the following techniques: <ul style="list-style-type: none"> <li>• Content that engages students with important content and processes</li> <li>• Activities that promote cognitive demand</li> <li>• Activities that involve students equitably at each phase of learning</li> <li>• Activities that promote agency, ownership, and identity over the content</li> <li>• Formative assessment and feedback are built into lessons</li> <li>• Activities should involve interaction with peers, parents, and teachers as required</li> </ul>

<p>Kuromiya, H., Majumdar, R., Miyabe, G., &amp; Ogata, H. (2022)</p> <p>Japan</p> <p>Junior High School</p>	<p>Moore's Interaction Model</p>	<p>Curriculum delivered via the Learning Evidence Analytics Framework (LEAF) platform</p> <ol style="list-style-type: none"> <li>1. Students received learning materials for 1 week (20 hours of study) every Monday morning via the LEAF platform</li> <li>2. Students created a self-study plan (4 hours a day) and were able to decide which subject they would study on each day of the week</li> <li>3. Students followed instructions and assignments included in the materials provided</li> </ol>
<p>Rice, R., Abhari, K., &amp; Pesavento, M. (2021)</p> <p>United States</p> <p>K-12</p>	<p>Authentic Social Learning Model (ASLM) in the context of social learning in Computer-Supported Collaborative Learning (CSCL)</p>	<p>ASLM lessons must include the following:</p> <ul style="list-style-type: none"> <li>• Social exploration</li> <li>• Social ideation</li> <li>• Social experimentation</li> <li>• Social validation</li> </ul> <p>Teachers learnt the ASLM model in a professional development program and provided portfolios with the following:</p> <ul style="list-style-type: none"> <li>• Reflections related to course topics</li> <li>• ASLM lesson plans</li> <li>• Samples of student work</li> <li>• Reflections on each lesson</li> </ul>

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**3.1.4.4.1 Efficacy, Outcomes, and Measures.** The article from Foster, Burkhardt, & Schoenfeld (2022) outlines and discusses an intervention without conducting an evaluation of its efficacy or measuring student engagement. The authors provide an evidence base and an in-depth explanation of the proposed method.

The article from Abouhashem et al (2021) measured engagement through the student retention rate of each course, which ranged from 89-100%, they also had students rate their experience of the course at the end of each session, it was found that students rated the courses more positively as they completed more sessions. Researchers used data from course session videos and presentation documents, an open-ended questionnaire as mentioned above, as well as students' assignments and attendance in the courses.

Kuromiya et al (2022) reported that student engagement in the online courses decreased for all grade levels across all subjects after three weeks of the intervention. There were differences noted in engagement between subjects and the junior high second year students were reported to be the least engaged. Engagement in this study was measured through online learning logs, students time spent on learning tasks, and average completion rate of the study material. Researchers also administered a survey to students to evaluate their perception of the intervention. Recommendations were made based on the measured engagement and the self-reports from the students.

Rice, Abhari, & Pesavento (2021) present a case study exploring the efficacy of a social learning model when delivered via virtual learning. The results were drawn from portfolios provided by the teachers that delivered the intervention using structural and pattern coding, which were used to develop key themes. Quotes from teachers were included in the article to substantiate results. Teachers in this case study reported improved student collaboration, more active engagement in class discussions with peers and teachers, and increased attendance rates. The authors reported that the intervention had positive impacts on classroom communication, collaboration, and engagement in all classes, not just those that were planned with their model.

**3.1.4.4.2 Recommendations from Authors.** Abouhashem et al (2021) suggest that further application and research that target students with academic and other challenges, could improve the efficacy of the intervention. The authors also reported that during the delivery of the course student feedback was regularly collected and used to alter the techniques of teachers to improve the course, for example, more time to finish learning tasks, or muting students during teaching sessions.

Foster, Burkhardt, & Schoenfeld (2022) present a model for use in online mathematics education, although the authors also suggest that the model is applicable within a broader

education context. The article outlines a model of strategies and techniques to improve engagement and pedagogical techniques during remote learning, the authors suggest future research and evaluation of the intervention could assist with designing curriculum that is crisis ready in the event of future educational interruption.

Both articles from Kuromiya et al (2022) and Rice, Abhari, & Pesavento (2021) recommend that online teaching include synchronous teaching and learning, to promote collaboration and engagement. In the article from Kuromiya et al (2022), it was recommended that in order to foster student motivation in online learning, the online platform could provide a way to display student progress, as well as providing possible learning plans for students. It was suggested that this would promote collaboration between students to alleviate anxiety about where they should be up to in their courses, and how to pace their learning. It was also recommended that students be provided orientation and training to use digital platforms, as well as ongoing technology support.

Rice, Abhari, & Pesavento (2021) suggest that future research into the intervention adapts the model to other learning modalities, for example, face-to-face, and hybrid learning. Authors also recommended that future research into the model aims to improve collaboration and engagement, include other social and collaborative technologies to improve the model, as well as replicating the intervention to verify its validity.

**3.1.4.4.3 Critical Appraisal.** Through quality appraisal using the MMAT (Hong et al, 2018), it was found that the article from Abouhashem et al (2021) did not address potential response bias. Students were asked to evaluate their experience of the course at the end of each session, this frequent data collecting, especially from children, could impact the responses given by the students. It is also noted that the measure of the student's 'innovation' each course was reported at 100% and it is unclear what the criteria was to determine student 'innovation'.

The data collection methods from Rice, Abhari, & Pesavento (2021) focus on teacher's experience and perception of the intervention. The only data collected from students was the work that the teachers included in their portfolios. There was also potential bias as the teachers who delivered the intervention were in a professional development program and may have had incentive to report positive results.

There were no issues with quality found in the appraisal of the article from Kuromiya et al (2022).

As the article from Foster, Burkhardt, & Schoenfeld (2022) did not evaluate an intervention, there was no quality appraisal performed using the MMAT. It is noted that the model presented draws on evidence based pedagogical techniques.

**3.1.4.5 Radio Learning.** There were two articles included that implemented pedagogical strategies that were designed to be delivered by radio. These interventions targeted students in remote areas, who may have multiple barriers to accessing education, many which were exacerbated due to COVID-19 restrictions and related school closures. The citation details, target school level, theoretical framework, and key features of each article are presented below (Table 5).

**Table 5***Characteristics of Articles Included Utilising Radio Learning Pedagogy Strategies*

Citation Details, Country, and Level of Schooling	Theoretical Framework	Key Features
Ebubedike, M., Boampong, M., James, K., Shuaibu, H., & Monyeh, T. (2022)  Nigeria  Primary and Secondary School	Holmberg's Conversational Learning Approach Theory	Radio School lessons were designed with the following features: <ul style="list-style-type: none"> <li>• Children could listen independently or in listening groups hosted by local learning facilitators</li> <li>• Lessons were broadcast three times a week by volunteer teachers</li> <li>• Primary school students' lessons were broadcast on Mondays in the following subjects, numeracy, literacy, and English language</li> <li>• Secondary school students' lessons were broadcast on Wednesdays in the following subjects, STEM subjects and English language</li> <li>• Lessons ran for 30 minutes and covered three subjects for ten minutes each</li> <li>• Repeat lessons were broadcast on Fridays</li> <li>• Instructional materials for lessons were designed to be consistent with the Nigerian Education Curriculum</li> <li>• Broadcasts were made in the local languages of Hausa and Fulfulde</li> </ul>
Prahmana, R. C. I., Hartanto, D., Kusumaningtyas, D. A., Ali, R. M., Muchlas. (2021)  Indonesia  K-12	Community Radio- Based Blended Learning Model (CR- BBLM)	CR-BBLM is designed with four features: <ol style="list-style-type: none"> <li>1. Involvement of learning organisers in remote areas to establish, manage, evaluate, and monitor community radio operations</li> <li>2. Clarity of the school's academic community audience, including organisers and local community</li> <li>3. Limited broadcast range around a particular school community that is intended for learning activities between teachers, students, schools, and parents of students</li> <li>4. Technology and costs that are suitable to the learning organisers and members of a school community in a remote area</li> </ol>

**3.1.4.5.1 Efficacy, Outcomes, and Measures.** The article from Prahmana et al (2021) outlines and discusses an intervention, with no evaluation conducted. Although an extensive literature review and evidence base is presented in conjunction with the developed model.

Ebubedike et al (2022) conducted interviews with students, local learning facilitators, and parents/guardians 16 weeks into the intervention and again in early 2021, after schools had reopened. Through qualitative analysis of the interviews, it was found that there were some challenges in involving students in the intervention due to economic hardships and families wanting students to work or assist with home duties, particularly for girls, who needed a male family member to approve of them attending school. Overall, the reports from participants were positive and indicated that the intervention allowed for students to access education and re-engage in learning during school closures due to COVID-19. This was especially true for girls, some of whom had never engaged in school due to various socio-economic barriers, which were at risk of being exacerbated due to the pandemic, this was reported to be a significant outcome of this intervention.

**3.1.4.5.2 Recommendations from Authors.** Ebubedike et al (2022) highlight the important of teaching in local languages to promote engagement in schooling. The authors report this to be especially important in the setting of the intervention, where school accessibility was already a barrier to engagement and was only exacerbated by school closures due to COVID-19. The authors recommended that teachers be provided with support to address the needs of students with special learning needs, this was suggested in the form of a network of practice and programs to support educators' professional development.

Prahmana et al (2021) present a model that is a recommendation of how radio learning can be implemented to promote student engagement in education in remote communities, where COVID-19 has exacerbated accessibility to schooling. The main component of this model is the involvement of communities in developing and managing radio learning programs.

**3.1.4.5.3 Critical Appraisal.** It was noted that the article from Ebubedike et al (2022) had similar limitations with data collection methods as other articles set in remote locations. This is reflected in the need for the communities involved in the intervention to use alternative

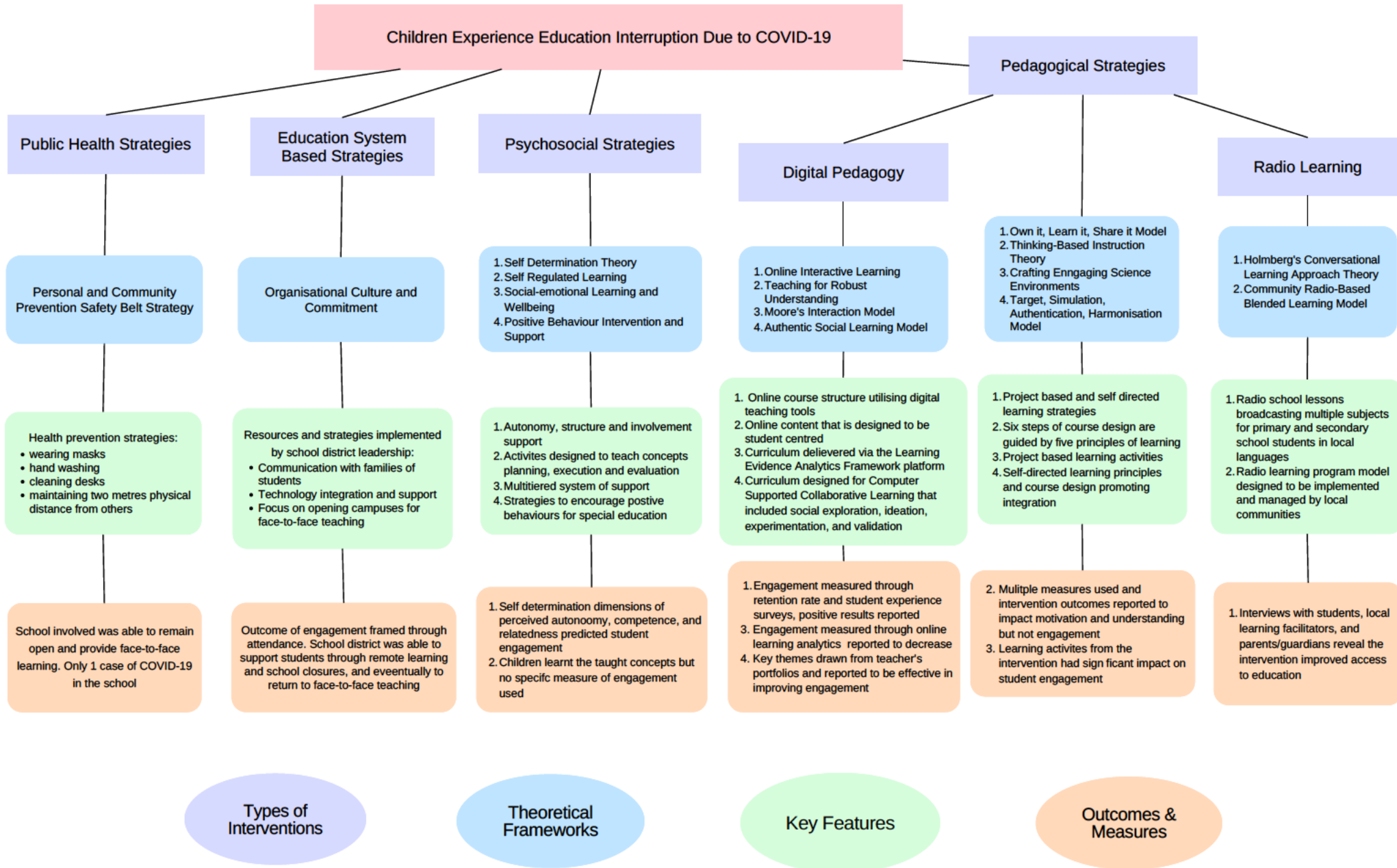
resources to access education, and it is understandable that researchers would face similar difficulties.

As the article Prahmana et al (2021) did not evaluate an intervention, there was no quality appraisal performed using the MMAT. It is noted that the article includes an extensive literature review that was used by the authors to develop the model presented.

### **3.2 Synthesis of Results**

Based on the findings from the included articles, a summary of results as they relate to the scoping review objectives is provided in Figure 2. The diagram depicts each type of intervention and the associated theoretical frameworks, key features, as well as outcomes and measures, as a response to children experiencing education interruption due to COVID-19.

**Figure 2**  
*Summary of Scoping Review Findings*



Types of Interventions

Theoretical Frameworks

Key Features

Outcomes & Measures

## 4. Discussion

The sixteen included articles in this scoping review represent a broad and diverse range of interventions for children experiencing educational interruption due to COVID-19. The findings provide an overview of the approaches used in various countries and contexts, encompassing a variety of theoretical approaches and features.

The goal of this review was to determine the response of educational systems to the restrictions and interruption of children's schooling due to the public health prevention mandates and associated disruption caused by the COVID-19 global health crisis. The diverse countries represented in this review reflect the global impact of COVID-19, which is also reflected in the methods that interventions used, in response to the specific public health requirements that were mandated in different locations. This review reflects instances where these efforts were documented and focused specifically on student engagement in education.

The four types of intervention highlight the different approaches to solving the issue of educational interruption due to COVID-19. In the case study from Kwon, Kang, and Kim (2021) the utilisation of public health strategies mirrors the most common intervention to the spread of COVID-19 and demonstrates how these strategies were utilised to serve two main purposes, reducing transmission of COVID-19, and allowing students to engage in face-to-face education. The ability to access school in the first place is essential to promote educational engagement, by removing the barrier of health safety, the school was able to provide the students a safe environment to attend in person. Utilising techniques of health literacy, the school was able to involve students in their own health safety, promoting understanding and ownership of health prevention strategies.

The case study from Childs, Groom, and Mozley (2022) demonstrated a similar example of existing resources and strategies being repurposed in response to the needs of students changing due to school closures and restrictions to education caused by COVID-19. The

communication to students and their families to maintain connection to the school community and to ensure information is accurate, reflects efforts from public health organisations and government departments during COVID-19, especially during lockdowns.

The psychosocial strategies highlight the importance of ensuring that children are providing with the resources to develop social and emotional skills, something that has been noted to be an area of concern due to the changes in the functioning of society due to COVID-19 and children not being in a variety of social contexts. As the article from Minkos & Gelbar (2020) highlights, there is a risk that children who would normally be noticed to be experiencing developmental, emotional, or behavioural challenges in a school environment are more likely to be at a further disadvantage due to the disruption in their education. This theme was also noted in articles not included in the scoping review that discussed how reports of children experiencing abuse have reduced due to children not being in school, where teachers are mandatory reporters (Handi et al., 2021).

The pedagogical strategies represent the teaching and learning techniques developed and adapted to meet the needs of students unable to access education in a traditional classroom. Many of these strategies involved some aspect of online or distance learning but were adaptable to various contexts. These strategies utilised theories of learning that have been developed prior to the pandemic, such as project based and self-directed learning, which have traits that lend themselves to more independent styles of learning, which were made necessary in instances of school closure.

Many of the included articles suggested further research and planning for future instances that may require school closure or students learning remotely.

#### **4.1 Limitations**

The initial database searches produced 16,752 results, of which, only 16 articles met inclusion criteria. The prolific publication around COVID-19 and the disruption to existing

research meant that including search terms relating to COVID-19 introduced a large number of irrelevant results. In terms of replicability, it is recommended that future reviews looking into phenomenon related to COVID-19 include more stringent search terms, especially when it comes to the related topics. Upon reflection, this scoping review would have benefitted a search strategy that excluded results to do with higher education, and other irrelevant themes.

Due to the recency and impact of COVID-19, it is noted that the research included in the current review was limited in terms of replicability of results, access to participants and resources, and being fast-tracked to respond to a real-time phenomenon. All of these factors contribute to the quality of the research produced, which is not surprising given the proximity of the included articles to the beginning of the pandemic.

There were constraints on the timeline of the scoping review due to the primary author contracting COVID-19. Although this impacted the speed and efficiency of the research, it was a first-hand reminder to the research team of the disruption that COVID-19 can have on education. An experience that is not isolated to this research or the primary authors education, but an example of how the COVID-19 pandemic continues to impact education almost three years after it begun.

## **4.2 Recommendations**

The vast impact of COVID-19 has resulted in various areas of interest and potential avenues for research to take. During the article screening process, some themes emerged, and while the articles did not meet inclusion criteria, there are potential areas of interest for future research into interventions and impacts of COVID-19 on children's education, health, and development.

An area of interest is how existing education programs adapted following disruption due to COVID-19 (Gadja et al., 2022). Specifically, education programs that provided services for

children already experiencing an interruption to their education, whether that be due to health issues, environmental disasters, or global socio-political crises, such as children who are refugees. The current review did include some programs that adapted in response to COVID-19 but the majority of the students in the included articles were experiencing interruption directly due to COVID-19 and only a few articles discussed other barriers to children engaging in education (Cunha et al., 2021; Ebubedike et al., 2022; Prahmana et al., 2021). Programs already addressing inequality and disruption to education prior to the COVID-19 pandemic can provide extensive knowledge and practices to future interventions and research on the impact and response to COVID-19 educational interruption.

During the screening process there were a number of articles that focused on the impact of COVID-19 school closures and lockdowns on children's physical health. This was in the context of how Physical Education lessons adapted to ensure that children were able to stay active, as well as the physical and mental health outcomes of reduced physical activity (Vilchez et al., 2021). While these studies weren't strictly focused on student's engagement in overall education, they explored how disruption to schooling has impacted on student's health outcomes.

Future research could focus on replicable results and longitudinal studies to validate interventions. Development of interventions could integrate aspects of the four types of intervention identified by this study and address potential learning and developmental delays caused by the interruption of COVID-19.

### **4.3 Conclusion**

The current scoping review aimed to collect information, identify and summarise current research, and establish an area for further enquiry regarding interventions for school engagement for children experiencing educational interruption due to COVID-19. Through

conducting a search of relevant databases and applying inclusion criteria, 16 articles were identified to answer the review question. Analysis of the included articles revealed four types of intervention, of which a summary of theoretical frameworks, key features, outcomes and measures used, as well as a critical appraisal were completed. Based on the results, suggestions were made for future directions of research, intervention design and implementation.

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## Children and Youth Services Review: Guide for Authors

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The following excerpts were used in preparation of this article for submission to the Master of Psychology (Health) thesis:

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A concise and factual abstract is required. The abstract should state briefly the purpose of the research, the principal results and major conclusions. An abstract is often presented separately from the article, so it must be able to stand alone. For this reason, References should be avoided, but if essential, then cite the author(s) and year(s). Also, non-standard or uncommon abbreviations should be avoided, but if essential they must be defined at their first mention in the abstract itself.

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Immediately after the abstract, provide a maximum of 6 keywords, using American spelling and avoiding general and plural terms and multiple concepts (avoid, for example, 'and',

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Collate acknowledgements in a separate section at the end of the article before the references and do not, therefore, include them on the title page, as a footnote to the title or otherwise. List here those individuals who provided help during the research (e.g., providing language help, writing assistance or proof reading the article, etc.).

### **Reference style**

Text: Citations in the text should follow the referencing style used by the American Psychological Association. You are referred to the Publication Manual of the American Psychological Association, Seventh Edition, ISBN 978-1-4338-3215-4, copies of which may be ordered online.

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## Appendix A – Quality Appraisal of Included Articles

**Table 6**

*Qualitative quality appraisal using criteria specified by the MMAT (Hong et al, 2018)*

Citation details & Type of Intervention	1.1 Is the qualitative approach appropriate to answer the research question	1.2 Are the qualitative data collection methods adequate to address the research question	1.3 Are the findings adequately derived from the data	1.4 Is the interpretation of results sufficiently substantiated by data	1.5 Is there coherence between qualitative data sources, collection, analysis and interpretation
Childs, J., Grooms, A., & Mozley, M. P. (2022) Education System Based Strategies	✓	✓	✗	✓	✓
Kwon, I., Kang, S., & Kim, J. S. (2021) Public Health Strategies	✓	✗	✓	✓	✓
Cunha J., Silva C., Guimarães A., Sousa P., Vieira C., Lopes D., & Rosário P. (2021) Psychosocial	✓	✗	✓	✓	✓
Rice, R., Abhari, K., & Pesavento, M. (2021) Digital Pedagogy	✓	✗	✓	✓	✓
Ebubedike, M., Boampong, M., James, K., Shuaibu, H., & Monyeh, T. (2022) Radio learning	✓	✗	✓	✓	✓

**Table 7**

*Quantitative non-randomised quality appraisal using criteria specified by the MMAT (Hong et al, 2018)*

Citation details & Type of Intervention	3.1 Are the participants representative of the target population	3.2 Are measurements appropriate regarding both the outcome and the intervention	3.3 Are there complete outcome data	3.4 Are the confounders accounted for in the design and analysis	3.5 During the study period, is the intervention administered as intended
Chiu, T. K. F. (2022) Psychosocial	✓	✓	✓	✓	✓

**Table 8**

*Mixed methods studies quality appraisal using criteria specified by the MMAT (Hong et al, 2018)*

Citation details & Type of Intervention	5.1 Is there an adequate rationale for using a mixed methods design to address the research question	5.2 Are the different components of the study effectively integrated to answer the research question	5.3 Are the outputs of the integration of qualitative and quantitative components adequately interpreted	5.4 Are divergences and inconsistencies between quantitative and qualitative results adequately addressed	5.5 Do the different components of the study adhere to the quality criteria of each tradition of the methods involved
Li, Y., Zhang, X., Dai, D. Y., & Hu, W. (2021) Pedagogy	✓	✓	✓	✓	✗
Maestres, S., Dezendorf, M. R., Tang, X., Salmela-Aro, K., Bartz, K., Juuti, K., Lavonen, J., Krajcik, J., & Schneider, B. (2022) Pedagogy	✓	✓	✓	✓	✗
Abouhashem, A., Abdou, R.M., Bhadra, J., Santhosh, M., Ahmad, Z., & Al-Thani, N.J. (2021) Digital pedagogy	✓	✓	✓	✓	✗
Kuromiya, H., Majumdar, R., Miyabe, G., & Ogata, H. (2022) Digital pedagogy	✓	✓	✓	✓	✓

## Appendix B – Measures and Practical Suggestions from Chiu (2022)

The following excerpts are the measures used and practical suggestions from the article by Chiu (2022).

### Instruments

Apart from demographic data, the pre- and post-questionnaires included seven variables in two categories: need satisfaction and student engagement. Each of the variables was scored using 5- point Likert scale items that were adapted from previous studies; reliability and validity were strong, as specified below. The items were also checked by two experienced teachers to make sure that the wording and language were understandable. Details of the instruments are described below.

### Need satisfaction

To assess the degree to which the students experienced satisfaction of the three needs, this study used two previously validated questionnaires. To measure the students' sense of autonomy, this study adapted five items from previous work conducted in the context of British children by Standage et al. (2005), with acceptable internal reliability (Cronbach's  $\alpha$  1/4 .80). The items were slightly modified to fit this study goal. Examples of items include "I have some choice in what I want to learn," "I have a say regarding what skills I want to learn," and "I can decide which activities and tools I want to learn."

Perceived competence toward online learning was measured using five items from the study on perceived competence by Standage et al. (2005), which showed acceptable reliability ( $\alpha$  1/4 .87) in similarly aged groups. Two example items are "When I have participated in online learning, I feel pretty competent" and "I am pretty skilled at learning online."

Participant-perceived relatedness to teachers was measured using the acceptance subscale of the items ( $\alpha$  1/4 .87) from Standage et al. (2005). Originally developed to assess the need for relatedness in physical education, the question was modified in this study as follows: "With the other students in my online learning, I feel XXX," followed by five options including "close," "valued," and "supported."

### Student engagement dimensions

Behavioral engagement in online learning was measured using five items from the study of Skinner et al. (2009) with acceptable reliability ( $\alpha$  1/4 .72). Their participants were school students who were at the same education level as the students in this study. Their items were modified to fit our research goal, for example, "When I'm in online learning, I listen and read very carefully," "I try hard to do well in online learning activities," and "When I'm in online learning, I participate in synchronous and asynchronous discussions."

Emotional engagement was assessed using five items with acceptable reliability ( $\alpha$  1/4 .82) from the study of behavioral engagement by Skinner et al. (2009). Three example items are "When we work on something in online learning, I feel interested," "This online learning is fun," and "I enjoy learning new things in online learning."

Cognitive engagement was measured using five items adapted from the study by Wang et al. (2016). They validated and verified items to measure middle and high school students' cognitive engagement in science and mathematics, which exhibited high internal consistency ( $\alpha$  ! .75). These items suited our participants and subject domains: for example, "I go through the work for online learning and make sure that it's right" and "I think about different ways to solve a problem."

To measure the students' agentic engagement, this study adapted five items from the work of Reeve (2013), who defined the concept of agentic engagement, for example, "I let my teacher know what I need and want in online learning," "During online learning, I express my preferences and opinions," and "When I need something in online learning, I'll ask the teacher for it."

### Practical suggestions

Other than the proposed digital support strategies, this study offers teachers two practical suggestions to satisfy the three needs for better engagement in technology-enhanced learning, and one practical suggestion to rapidly engage students during school closures in times of societal and/or public health crisis (e.g. COVID-19). The first suggestion for teachers is to design and produce teaching-efficient videos. The most effective videos have four key features. First, they use a multiple representation approach that better covers the complete domain and elicits a wider range of learning processes to provide various learning resources (see Autonomy (i) in the proposed model; Jaakkola & Veermans, 2020). Second, they apply Mayer's multimedia learning principles to provide guidance on how to create effective multimedia to develop teaching materials (see Competence (ii), Chiu & Churchill, 2015; Chiu & Churchill, 2016b). Third, they are designed for mobile technologies and small screens that require less bandwidth so that students, particularly the economically disadvantaged, can easily view and use learning materials via their phones (see Competence (ii); Chiu & Churchill, 2015). Last, they use an emotionally literate design approach to develop joyful and fun learning materials (see Relatedness (ii); Chiu et al., 2020).

The second suggestion for teachers is to improve their digital communication skills for technology-enhanced teaching (see Relatedness (iii)). Enhancing one's skill in evincing a positive attitude and enthusiasm online to foster relatedness can help positive teacher–student relationships and better emotionally engage students in learning. For example, emoji can be used in replies to messages in forums, and feedback can be given as warm and friendly audio messages.

The last suggestion is for schools and teachers to establish and activate an emergency transition to an online learning protocol in times of societal and/or public health crisis. Our findings indicated that relatedness is the most important among the three needs in student engagement (see the final empirical implications). Schools and teachers should ensure that the primary concern of online learning is supporting relatedness. Accordingly, this study suggests that schools should (i) redesign timetables to provide students with an online space to socially interact with their teachers and peers to build a stronger sense of belonging; (ii) arrange mental health activities to let students express their emotions, for example regarding life during school closure; and (iii) formulate online teaching strategies or curriculum guidelines, such as establishing online peer support groups, adopting “learning more and evaluating less” assessment approaches, and including more interdisciplinary learning activities.

## Appendix C- Measures used from Li et al (2021)

The following excerpts are the measures used in the article from Li et al (2021).

### Measurements

#### Course Experience Questionnaire

Students' perceptions of the quality of their courses were measured by the Course Experience Questionnaire (CEQ) (Eley, 1998). It was originally designed by Ramsden (1991) and was adapted into a simplified version of 23 questions by Eley (1998) and has been widely used to evaluate teaching quality at the curriculum level (Byrne and Flood, 2003). CEQ consists of five subscales: good teaching, clear goals, appropriate workload, appropriate assessment, and generic skills. Considering our purpose of examining the quality of the course, only the last four dimensions were adopted (the "good teaching" part was excluded), with a total of 17 questions ( $\alpha = 0.86$ ). Students were asked to respond on a five-point Likert scale (1 = "strongly disagree," 5 = "strongly agree"). Example items are "It was always easy to know the standard of work expected" and "The workload was too heavy."

#### Mayer Learning Experience Questionnaire

The Mayer Learning Experience Questionnaire (Moreno and Mayer, 2000; Stull et al., 2018) was used to measure students' learning experience in terms of motivation, interest, understanding, the perceived difficulty of the material, and engagement. The scale contains eight items and was scored on a seven-point Likert scale ( $\alpha = 0.87$ ). An example item is "I enjoyed learning this way."

#### Online Learning Behavior Questionnaire

Three subscales (i.e., interactive communication, persistence, and learning attitude) from the Online Learning Behavior Questionnaire (Li et al., 2013) were used to measure students' online learning behaviors in traditional courses as well as thinking-based online micro-courses. The three subscales contain 12 items in total and were scored on a five-point Likert scale ( $\alpha = 0.86$ ). An example item is "I am willing to share my ideas with my classmates in the TBIT-based micro-courses (or 'in the national curricula')."

#### Informal Interviews Toward Teachers' Perspectives on the Thinking-Based Courses

In addition to the questionnaires for students, informal interviews were conducted for teachers to qualitatively evaluate their perspectives toward the TBIT-based micro-courses. Four open-ended questions were used in the informal interviews: "Compared with previous courses, what are the features of the TBIT-based micro-courses during the pandemic?", "How is the effect of TBIT-based micro-courses during the pandemic on improving students' thinking ability?", "How is the effect of TBIT-based micro-courses during the pandemic on improving students' key competence?", and "How about students' engagement in learning TBIT-based micro-courses?"

## Appendix D – Measures from Maestrales et al (2022)

The following excerpt is the measures used in the article from Maestrales et al (2022).

### Measures

#### *U.S. measures*

In the United States, the same students were followed through a full school year and surveyed in fall 2019 and again in spring 2020, after moving to remote learning. Students were asked to respond to questions about their demographic data such as race, gender, grade point average, and attitudes toward science. In both fall and spring, students were asked about their interest, skill, and challenge in their physics or chemistry class. Students reported how much they agreed with the following statements: I am interested in science; I feel skilled in science; and I find science challenging on a four-point Likert scale. To measure students' academic engagement, we calculated the mid-point for each of the three categories (i.e. interest, skill, and challenge). Academic engagement is the binary outcome indicating that a student reported scores above the midpoint (e.g. 3 or 4) for each of the three categories. We then compared their responses from fall to spring after the shift to remote learning.

Students also reported on how frequently they participated in a number of activities when in a remote classroom and how interested they were in each activity. These activities included: discussion boards; one-on-one video chats with the teacher; watching videos of experiments; online simulations; live lessons; recorded videos of lessons; using textbooks; writing papers; building models at home; making presentations using slides or power-point to share with the class; text-based instruction; working in groups through video chat; and experiments to try at home. Students' reported interest was ranked and compared to its reported activity frequency in the classroom. Frequency was measured on a 5-point scale: we do not do this activity (0); less than once every 2 weeks (1); once every 2 weeks (2); once per week (3); or every day (4). Interest here was reported on a four-point scale ranging from "this does not interest me (1)" to "this interests me a lot (4)."

On the fall and spring surveys, students responded to questions specifically related to project-based learning tasks associated with the CESE intervention. These activities were included to determine whether students were still able to engage in the same project-based tasks fundamental to the intervention. These questions were altered to better suit the situation of remote learning when administered on the second survey and additional questions related to modelling were added. In fall, these were measured on a scale similar to those that were specific to online learning and where students reported the frequency with which they performed certain activities: never or almost never (1); once every month (2); once every 2 weeks (3); once per week (4); or more than once every week (5). These activities included several different types of modelling activities, opportunities to take pride in their achievements, ask questions in class, discuss phenomena, work together to solve problems, generally present their findings, and the frequency with which students performed "science and engineering practices like taking measurements to collect data about the world around us and using evidence to make a claim."

To understand the relationship between social and emotional skills and students' academic engagement, college ambition was considered a behavioural measure of persistence (or grit). On both the fall and spring surveys, students were asked to report their educational goals regarding how far they expect to go in school, including: I do not know how far I will go; less than high school; graduate from high school but not go any further; go to a vocational, trade, or business school after high school; graduate from a two-year college (Associate's Degree); graduate from a four-year college (Bachelor's Degree); Master's Degree or Equivalent; and Ph.D., M.D., or other advanced professional degree. A binary variable was created to indicate whether or not a student reported plans to attend at least 4 years of college.

### ***Finnish measures***

In Finland, the CESE study focused on situational engagement and researchers did not follow the same students through an entire school year. During the pandemic, students were asked to complete two surveys. The first survey focused on their general feelings and experiences in remote learning during the pandemic. The second survey asked students to report their real-time feelings and experiences using a diary format, the experience sampling method (ESM), for which they answered short surveys in the moment, during their remote lessons.

Situational engagement consists of high levels of interest, skill, and challenge. Students reported in the ESM survey their momentary interest (Are you interested in what you are doing?), skill (Do you feel skilled at what you are doing?), and challenge (Do you feel challenged by what you are doing?) on a four-point scale of: not at all (1); a little (2); much (3); and very much (4). Academic engagement was measured similarly in both countries. Students were considered situationally engaged (i.e. OLM) if their responses were 3 or 4 to all three questions. A binary variable of 1 or 0 was generated to indicate whether this was an OLM or not.

The ESM survey asked students to report their practices when they received the survey. They could choose from: following teacher's instruction, doing tasks independently, studying from books, studying from the website, writing, discussing online, making videos, asking questions, developing a model, using a model, planning an investigation, conducting an investigation, analysing data, solving math problems, constructing an explanation, using evidence to make an argument, evaluating information, and other. Students chose all practices that applied to them. These options were recoded as dichotomous variables for the analysis (practice was reported (1) or not reported (0)). The ESM also surveyed students' social and emotional experiences in real-time on a four-point scale: not at all; a little; much; or very much. We focused on students' remote learning experience regarding their belief that the material had importance for their future; feelings of loneliness; boredom; confidence; curiosity; and grit as they have been high-lighted in the OECD social and emotional skills frameworks (Kankaras & Suarez-Alvarez, 2019; Salmela-Aro & Upadyaya, 2020). In total, these ESM surveys produced an average of 3.49 responses per student, for a total of 701 situational responses.

The general survey asked students to report how often they engaged in the following science practices on a four-point scale: never or hardly ever (1); some hours (2); most hours (3); and in all classes (4). The practices were: have opportunities to explain my own thoughts; plan how to study; do practical tests; draw conclusions from experiments or research; apply concepts related to everyday problems; participate in debate or discussion; follow the teacher's demonstrations; do experiments as instructed; follow the teacher's teaching or example in remote learning; view a video or animation; do assignments independently; study a book, study a website or e-learning platform; make notes or summaries; share documents with other students; present my output in a video conference (Zoom, Meet, Skype, etc.); write a joint document with another student; chat online; create videos or animations; do experimental research with tools found at home; ask for advice from another student; help another student; and get feedback from the teacher that promotes learning.