Computer Science and Montessori Education Integration: An Annotated Bibliography

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EDCI 515: Technology-Mediated Research Methods

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Ahmed Sayed Ali, S., Chettaoui, N., Atia, A., Bouhlel, Med. S., & Mohamed Abdel Mohaiman, D. (2023). A futuristic design vision of tangible user interfaces on enhancing Montessori. *Interactive Learning Environments*, *31*(8), 4940–4955. https://doi.org/10.1080/10494820.2021.1987275

This article aimed to create a new hybrid of Montessori learning called "Interactive Technology Montessori" (ITM) where Montessori learning objectives are mitigated through digital interfaces. Through the use of a high-engagement digital medium, ITM aimed to promote student choice and freedom in learning, while providing instant feedback to students. To study the effectiveness of ITM, researchers created a learning opportunity based on setting a table for mealtimes using conventional Montessori methods, and recreated the same lesson using a digital medium, then allowed students to use real materials to demonstrate their learning with digital feedback on the screen used in the lesson. Students using the ITM method to learn completed the learning objective faster than students learning the traditional way. They also had a smaller margin of error when recalling the placement of objects on the table. Teachers and students surveyed ranked the ITM activity as highly engaging. Teachers also rated the activity as age-appropriate and more effective than the standard Montessori lesson. This article opens the discussion up for more research to be done into ITM and the conscious blending of Montessori learning and digital platforms.

Çakir, Z. Ç. Z., & Yalçin, D. D. S. A. (2020). Pre-School Teacher Candidates' Views on STEM Applications Based on Montessori Approach. *Turkish Online Journal of Qualitative Inquiry*, *11*(3), Article 3. https://doi.org/10.17569/tojqi.636526

This case study followed 50 preschool teacher candidates for 14 weeks and were asked to engage in STEM lessons rooted in the Montessori method. The goal was to gain understanding on their perspective on the viability of STEM being blended into Montessori education. They were placed in groups in which they were tasked to create a learning experience based on simple building challenges, coding and robotics, and text-based coding. The groups then had to present the design alongside the materials. The teachers made considerations that the materials and topics must be age appropriate for the students. Their attitudes were mostly positive to the simple build challenges, but more apprehensive about introducing robotics and coding to children. Their concerns were focused on the topic being too complex for students at the preschool level. They also noted that the use of STEM education could be applied to many different topics for learning and could be very memorable for students. Not only were these activities engaging and fun but could be motivational for students to explore more on their own. Overall, the candidates were highly motivated to utilize STEM and Montessori education in their own practice.

Jones, S. J. (2017). Technology in the Montessori Classroom: Teachers' Beliefs and Technology Use. *Journal of Montessori Research*, *3*(1), Article 1. https://doi.org/10.17161/jomr.v3i1.6458

Jones' article looked to gain insight into Montessori teachers' ideologies on technology used in the Montessori classroom, and if teachers are utilizing the Technological Pedagogical Content Knowledge (TPACK) model when technology is being used. Four lower elementary Montessori teachers from a single school were studied. Teachers were interviewed, observed in class, and observed in group meetings with the other study subjects with researchers taking notes using a TPACK rubric. The subjects were also required to submit lesson plans that were also assessed using the same rubric. A final teacher case was developed on each educator to summarize all the data. Teacher responses to technology use in their classrooms ranged from little to no use by students and teachers, to students-centered computer use to research and express their learning. All teachers recognized that the use of technology was an important tool, but often questioned the quality of the programming catered to the Montessori curriculum. Technology used in their classrooms was not being used in a transformative way mostly due to the lack of time allotted while using the technology, inability to find appropriate and consistent resources, and dismissing programs available as not a good fit for the Montessori classroom. This study suggested that school administrators and district officials must re-assess the devices and programming they offer to schools to make sure technology use is equitable for all.

Livstrom, I. C., Szostkowski, A. H., & Roehrig, G. H. (2019). Integrated STEM in practice: Learning from Montessori philosophies and practices. *School Science and Mathematics*, *119*(4), 190–202. https://doi.org/10.1111/ssm.12331

Livstrom and Szostkowski's article focused on how Montessori middle schools integrated Science, Technology, Engineering, and Math (STEM) education into their science curriculum with relation to the Montessori philosophy of the middle grade "Erdkinder" student where farm work and business knowledge is pre-built into this classification of student. A preliminary survey was conducted to gather teacher and administration's knowledge of STEM education, Montessori pedagogy, and reform-based science. The survey shoed that the participants identified authentic work, community involvement, integrated STEM learning, holistic education, passion-based learning, and socially relevant connections to the learning as the pillars of their Montessori program. Because STEM education is cross-disciplinary in nature, the Montessori science curriculum was also cross-disciplinary. Larger projects with science integration were common and no subject in the project was discussed in a singularity. Pushing for a cross-curricular model, students became masters of "soft skills" and were practicing how to be a thoughtful member of their community. The researchers concluded that STEM integration in Montessori middle school settings is an ideal context for these learning ideals to meld together. There is a current lack of literature on science education in Montessori as is, so more research that discusses this context would be valuable.

Looijenga, A., Klapwijk, R. M., & de Vries, M. J. (2020). How focus creates engagement in Primary Design and Technology Education: The effect of well-defined tasks and joint presentations on a class of nine to twelve years old pupils. *Design & Technology Education*, *25*(2), 10–28.

This case study was interested in how larger STEM challenges broken into smaller, more manageable tasks in conjunction with accompanying presentations would impact student outputs and collaboration skills. This study was done in a Montessori classroom where the objective of making a mini chair was broken into ten smaller jobs. Each lesson had a specific technique tied to the objective. Research was collected during the lessons through observations and asking questions to students. Student engagement was also recorded for three of the sessions. The teacher presented the skills and objectives, while students began working on their tasks. Students needed to have completed each small job before moving on to the next job. During the sessions, instances of lack of motivation and self-starting behaviours occurred in a few students. During the final session, students completed their chair, and some extended the assignment with another independent job. They presented and displayed their work. The teacher expressed worry during the first two sessions but was relaxed by the end. The study showed that there was a significant increase in collaboration skills as the tasks got harder and harder. The designs became more high-quality, and a majority of students were highly engaged when they had smaller attainable learning objectives. Further research into the impacts of this style of teaching and learning was suggested in more traditional educational settings, since the study was originally rooted in Montessori and hands-on learning,

Owen, S. J., & Davies, S. (2020). Maintaining an empowered school community: Introducing digital technologies by building digital literacies at Beehive Montessori School. *London Review of Education*, *18*, 356–372. https://doi.org/10.14324/LRE.18.3.03

This article was a case study on how a Montessori school in Western Australia implemented a digital-literacies framework designed by the school, in collaboration with researchers from Curtin University, to assist in how they used technology in a classroom setting. The major concerns were if the constraints of Montessori education would support a student's digital literacy and if these technologies could align with the Montessori concepts of physical and intellectual independence. Educators were paired with a critical friend who would provide constructive criticism and share insights in a supportive manner. A survey was conducted to assess general technology knowledge of teachers. Results showed that teachers were unfamiliar with what digital literacy was and how it was taught in school. A professional development day was held in response to the survey data. The critical friend then observed teachers in their classrooms and provided feedback and a plan for what to do prior to the next observation. Educators identified that physical and intellectual independence could be achieved through a three-part lesson where the first two parts have students copying the teacher through technology use, and the third part having students explore the medium as to how it applies to them and extends their thinking. This three-part lesson model was integrated into a school-wide project to educate students on virtues. Teachers would follow the procedure of "say", "do", and "produce" in the three-part format to integrate technology into a Montessori method of instruction. This collaborative framework gave teachers a chance to try

something previously unfamiliar to them with the support of a peer and the school at large and re-contextualize how it could be integrated into the Montessori framework.

Owen, S., Davies, S., & Iles, S. (2021). Bridging Communities: Developing Digital Literacies and Introducing Digital Technologies in the Montessori Early Childhood Education Classroom. In Holloway, D., Willson, M., Murcia, K., Archer, C., & Stocco, F. (Eds.). (2021). *Young Children's Rights in a Digital World: Play, Design and Practice* (Vol. 23). Springer International Publishing. https://doi.org/10.1007/978-3-030-65916-5

This chapter focused on where there was evidence of digital literacy being taught in Montessori contexts. It discussed the ongoing controversial conversations as to whether digital technology has a space in Montessori education. Many researchers rejected technology as they felt it would stifle their creative thought and students should be taught different thinking strategies instead. Others suggested that if the technology was meaningful to the learning, followed the criteria that physical Montessori materials are upheld to, and could be used to mimic real life scenarios, digital devices and platforms could be considered Montessori appropriate materials. Considering these competing ideologies, a new study on early robotics integration was introduced to a Montessori early childhood education school. The study suggested that mere displaying of technology was not adequate, but rather teachers must be educated on how to apply the tools into their curriculum. Owen, Davies, and Iles referenced their previous study (see above) as an example of how digital literacies could be integrated into Montessori classrooms. Teachers could identify that students were using technology at home and felt excited

when they got the rare opportunity to use it in class, but while teachers saw the value of teaching with technology, they struggled with how to meaningfully integrate it. Using the Montessori structure called the three-part lesson, teachers could see an example of how digital literacy could be blended into lessons they had already been teaching. The idea that school and the parent community's attitudes toward technology should be aligned was also suggested as a further stretch to extend our understanding.

Ponticorvo, M., Di Fuccio, R., Di Ferdinando, A., & Miglino, O. (2017). An agent-based modelling approach to build up educational digital games for kindergarten and primary schools. *Expert Systems*, *34*(4), n/a-N.PAG. https://doi.org/10.1111/exsy.12196

Ponticoryo, Di Fuccio, and Di Fernando looked to reimagine the Montessori-like educational materials (MLEM) (i.e. tactile manipulatives, cards, tile puzzles, beads etc.) that often accompany traditional activity books, by introducing a digital option that can break down the expectation that the learning activity is an obstacle the student must perform. One material developed was "Block Magic" – a digital interface that could read data on shapes based on the traditional Logic block Box Montessori material and provide real-time feedback to learners. The program could make decisions on extending the learning for each student and give data to teachers on completion rates and skipped objectives. Another material developed was SNIFF – a program meant to integrate a learners' sense of smell by creating associations between a stimulus and a scent. From the proto-typed MLEMs with digital integration in mind, the researchers conclude that

bringing the Montessori materials into a digital space where teachers can have access to student data and truly be facilitators, rather than direct interventionists.

Scippo, S., & Ardolino, F. (2021). Computational thinking in Montessori primary school. *Ricerche Di Pedagogia e Didattica. Journal of Theories and Research in Education*, *16*(2), Article 2. https://doi.org/10.6092/issn.1970-2221/12163

In this longitudinal mixed-methods study, Scippo and Ardolino looked to see if robotics education could be mixed into Montessori education in a way that honours yet modernizes the philosophies. They argue that computational thinking itself is rooted in the Montessori method in which it is student directed and activate both body and mind during exploration. The first year of study had students colouring squares on a page to illustrate a naval battle, and learn about binary code's 0s and 1s set up. The second and third years had the students learning with Ozobot robots. Students would have to answer grammar questions in order to learn how the robot would respond to certain colour combinations. This activity culminated into students coding the robot to complete specific objectives and create a story to fit the narrative. The final two years of the study had the students using Lego WeDo robots shaped like crocodiles and they learned how to run simple codes and built their knowledge up to complete challenges with increasing difficulty. The study concluded that that the learning designs encouraged divergent thinking and allowed for students to engage in learning through repetition. Scippo and Ardolino also noted that the robotics materials used in the studies shouldn't be a replacement for the Montessori materials, but rather blended into them. Another major

consideration for this study was that any computational thinking material used in the classroom should not be available in the home where children need the space to play and practice social interactions with families. Despite not being available in homes, the material should be open in classroom for students as an option to support their learning. The study suggested that teachers should be using technology with a Montessori mindset, instead of dismissing technology as categorically not Montessori coded.

Scott, C. M., & Myers, B. (2021). Montessori Education: Teacher Perceptions of Challenges in Transitioning to Virtual Instruction. *Journal of Montessori Research*, *7*(2), Article 2. https://doi.org/10.17161/jomr.v7i2.15469

This article aimed to study how Montessori teachers integrated digital learning in an online learning situation considering the 2020 COVID-19 lockdown, their complications, and their positive outcomes. This study was framed as a qualitative data analysis with interviews and written outputs of teachers who participated in the study. The four teachers studied were either a lower elementary teacher (K-3) or an upper elementary teacher (4-6). All teachers mentioned that their main concerns for virtual instruction were supports for students, resiliency, accountability, and environmental influences. Teachers made time for students to check in with them and the class through facilitated lunchtime socials, and book talk times. The relationships that students had already made with peers and the teacher were helping students cope and provided more flexible learning opportunities that an in-school setting may restrict, a teacher reported. Teachers found that external factors such as, parents scheduling doctor's appointments mid-day, parents not being available

for helping with assignments, and the appeal of going to play video games with peers online set students up for failure in terms of not submitting work on time. There was a huge need to teach students how to take accountability for their work habits and learn to manage their time adequately. Teachers also pointed out that when the at-home and school environments became one entity, the students with no parental support were negatively affected, but the students with the opposite situation were positively affected. Educators tried to engage with families as a whole to bridge the gaps. Researchers suggested that more investigation be done into virtual learning alongside Montessori learning with the integration of supports for both students and families regarding time management, supporting frustration, and recognizing when you or your child need help in a myriad of contexts.