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IAFOR Journal of Education

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From the Editor

Dear Readers,

This is the third and final issue of the *IAFOR Journal of Education* for 2018. The eight articles again display the research being undertaken from a range of locations: the Philippines, Australia, Canada, Hong Kong, England, and the United States. While the contexts are different, the themes are relevant to educators globally.

The themes of the articles in this issue are as diverse as the countries from which they came. The research reported covers TPACK, artificial intelligence, social and emotional education, mathematics, child development workers, mentoring, learner-generated digital media, and conducting experiments prior to teaching of concepts.

We hope that you enjoy these articles, find application for them in your own contexts, and consider sharing your own research and experiences in the journal. The next issue is due to be published on June 1st, 2019.

A thank you to all who have submitted articles in 2018. The huge response we have had to calls for papers demonstrates the many research projects being conducted in the field of education.

Thanks go to all the reviewers throughout the year, many of whom have willingly accepted the role for more than one issue. Special thanks also to the associate editors, Lynda Leavitt, Massoud Moslehpour and Raimond Selke, who have made my job easier and to the IAFOR publications team for their hard work and dedication.

I look forward to building on our strengths throughout 2019.

Yvonne Masters
Editor, IAFOR Journal of Education,
ije.iafor.org

Notes on Contributors

Article 1: Mentoring Experiences, Issues, and Concerns in the Student-Teaching Program: Towards a Proposed Mentoring Program in Teacher Education

Dr Susan Galamay-Cachola has a PhD majoring in Educational Management. She is an Associate Professor / Faculty Researcher at Saint Mary's University, Bayombong, Nueva Vizcaya, Philippines. Her fields of expertise are Curriculum, Instruction, and Assessment; Action Research in Education; and Religious and Values Education.
Email: susangcachola@gmail.com

Dr Ma. Cristeta M. Aduca has a PhD majoring in Educational Management. She is Professor / Principal of the Grade School Department, Saint Mary's University, Bayombong, Nueva Vizcaya, Philippines. Her fields of expertise are Curriculum, Instruction, and Assessment and Religious and Values Education.
Email: tetaaduca@yahoo.com

Miss Federicia C. Calauagan has **a** Master of Arts in Education. She is an Associate Professor / Student Teaching Supervisor at Saint Mary's University, Bayombong, Nueva Vizcaya, Philippines. Her fields of expertise are Reading education and Professional education.
Email: lizac22@yahoo.com

Article 2: Work-Related Factors as Determinants of Self-efficacy and Resilience among Selected Filipino Child Development Workers

Ms Katherine del Rosario holds a Bachelor's degree in Human Ecology from the University of the Philippines at Los Baños, Laguna. She is also a graduate of Master of Family Life and Child Development from the University of the Philippines, Diliman. Her specialization is on early childhood development and education which includes management of preschool centers, teacher training and coordinating various activities. She is currently an Assistant Professor at the Department of Human and Family Development Studies, College of Human Ecology, UPLB where she handles courses on human development across the lifespan, conducts training for Child Development Workers and engages in research and extension programs of DHFDS.
Email: kedelrosario@up.edu.ph

Mr Nephtaly Botor holds a Bachelor's degree in Psychology and is presently serving as an instructor of the Department of Human and Family Development Studies, College of Human Ecology, University of the Philippines at Los Baños, Laguna. He is also a licensed psychometrician and a professional facilitator and trainer specializing in values education. Mr Botor is currently in the final stage of his Master of Education, specializing in Guidance.

Ms Jewely Jean Varca-Padilla is a graduate of BS Human Ecology from the University of the Philippines, Los Baños. She also earned her Master's degree on Family Resource Management from the same university. At present, she serves as a University Extension Associate at the Department of Human and Family Development Studies, College of Human Ecology, UPLB. She works as teacher-in-charge at the UPLB Child Development Laboratory (CDL), handling the nursery and pre-kindergarten classes. She develops and implements learning modules for the children and coordinates the activities and events at the CDL. She also assists in the research and extension activities of DHFDS.

Ms Aida Escobin holds a Master's degree in Family Resource Management from the University of the Philippines at Los Baños, Laguna. In 1990, she became a part of the Community and Family Life Education Laboratory (COMFA-LAB) under the Department of Human and Family Development Studies, College of Human Ecology, UPLB, as a Family Development Worker. Her duties include teaching preschoolers and coordinating activities and projects with parents. From 1995 to present, Ms. Escobin serves as University Extension Associate in the same department. She has over 25 years of work experience in the areas of teaching, research and administration. She also facilitates training for Child Development Workers in the Southern Tagalog Region.

Ms Daisy Pelegrina is a graduate of BS Development Communication from the University of the Philippines at Los Baños, Laguna and is currently in the process of writing her thesis leading to a Master of Science in Development Communication in the same university. At present, she serves as University Research Associate and Development Communication Specialist at the Department of Human and Family Development Studies, College of Human Ecology, UPLB. She works as a language editor, writer, and coordinator of various research and extension activities at both university and provincial (LGU) level which help fulfill DHFDS' vision to promote human development across the lifespan.

Article 3: Role of Educational Technologies Utilizing the TPACK Framework and 21st Century Pedagogies: Academics' Perspectives

Mrs Tirtha Goradia has a Bachelor's degree in complementary medicine from India and a Master of Education degree from Murdoch University (Perth). She also holds a Graduate Certificate in Tertiary and Adult Education from Murdoch University. Her thesis for her Master of education degree was "Strategies to enhance student engagement in online learning". Tirtha is currently a Senior Lecturer and e-learning specialist in the Biosciences department at Endeavour College of Natural Health, a leading complementary medicine provider in Australia. Tirtha's contributions to publication, conferences and webinars have been around higher education sector. Her research work explores concepts of self-regulated learning, online learning, technologies and pedagogies, evidence based practice and higher education. She has made various contributions in the teaching and learning space and worked on projects for first year students, online and blended learning and pathology and clinical science curriculum development.
Email: Tirtha.goradia@endeavour.edu.au

Article 4: Artificial Intelligence and the Student Experience: An Institutional Perspective

Ms Kriti Khare has a Master in Computing Science from University of Alberta and a Master in Education, specializing in technology in education. While pursuing higher education as a preservice teacher, she is involved with data analytics related to university services at the Information Services and Technology Department, University of Alberta. Her research interests include computing science education, inquiry-based learning, use of technology in education, and data mining.
Email: kriti@ualberta.ca

Mr Brian Stewart is the Deputy CIO at the University of Alberta. His role is to provide strategic leadership, vision, and direction for information services and technology and to direct business transformation through project and change management while also leading a lean

initiative for continuous operational improvement. Brian's background is in strategic, operational and technology management in the printing industry and higher education sector, and he has written and spoken widely on these topics. Brian has a Master of Arts in Economics from University College, Cork, and a Master of Business Administration from Athabasca University. He is currently a PhD student at the University of Eastern Finland.
Email: brianstewart3@gmailcom

Dr Anshuman Khare is Professor in Operations Management at Athabasca University, Canada. He is an Alexander von Humboldt fellow and a former *Monbusho* scholar. His research focuses on environmental regulation impacts on industry, just-in-time manufacturing, supply chain management, sustainability, cities and climate change, online business education, and so on. He is passionate about online business education and has won several awards as a testament to his commitment to exceptional online education. Anshuman serves as the editor of *IAFOR Journal of Business and Management* and associate editor of *International Journal of Sustainability in Higher Education* published by Emerald and is on the Editorial Board of *International Journal of Applied Management and Technology*. In 2017 Anshuman co-edited a book *On the Line: Business Education in the Digital Age* which was published by Springer.
Email: anshuman.khare@fb.athabascau.ca

Article 5: Teaching Them before We Teach: The Effectiveness of Conducting Classroom Experiments before Teaching the Underlying Theory

Dr Raymond Li is currently a teaching-track faculty member at the Hong Kong Polytechnic University. Dr Li received his formal training in Economics from Macquarie University in Australia and obtained his Bachelor of Economics with first class honours. He also obtained his PhD in Economics from Macquarie University. His primary research interests include applied econometrics, energy economics and energy policy. His research outputs appear in a range of international journals like the Energy Journal, Energy Policy and Applied Energy, amongst some others. Ray is an editorial board member of two international academic journals and he serves as ad hoc reviewer of research articles for various academic journals.
Email: ray.li@polyu.edu.hk

Dr Tina Wong is a teaching fellow at the Hong Kong Polytechnic University. She obtained her Bachelor of Social Science (Economics) from the Chinese University of Hong Kong and the Postgraduate Certificate of Education (Economics) from the University of Hong Kong. She had her further studies in the Hong Kong Polytechnic University (Master of Finance) and the University of Newcastle (Doctor of Business Administration). She has over 10 years' experience in teaching Economics and Finance.
Email: aftina.wong@polyu.edu.hk

Article 6: Learner-Generated Digital Media (LGDM) as an Assessment Tool in Tertiary Science Education: A Review of Literature

Mr Jorge Reyna is a Lecturer in Higher Education, Learning Design at the University of Technology, Sydney, Australia. He has vast experience applying pedagogies, instructional strategies, visual design, aesthetics, usability, and accessibility in online and blended learning environments, as well as teaching digital media to communicate science. Jorge's areas of expertise are in digital media production such as animations, screencast, podcasts, video scripting, filming, editing and production, multimedia learning, web design, graphics, and

photography. His current research includes the study of self-regulation and motivational processes in Learner-Generated Digital Media Assignments (LGDM) in science education.
Email: jorge.reyna@uts.edu.au

Associate Professor Peter Charles Meier is Associate Dean of Teaching and Learning at the University of Technology, Sydney, Australia. He is responsible for the implementation of new learning technologies and approaches across the science curriculum. Peter is a specialist in clinical learning and competency assessment, including virtual clinic environments. He is currently leading a nationally recognised lighthouse project in Work Integrated Learning in Science.
Email: peter.meier@uts.edu.au

Article 7: Towards a Cross-Cultural Conceptual Framework for Researching Social and Emotional Education

Dr Edurne Scott Loinaz is co-founder of HAHA Academy and completed her PhD at UCL's Institute of Education. Edurne's research interests lie in the area of social and emotional education, comparative education and the decentralisation of knowledge. She has collaborated actively with researchers in several other disciplines, particularly educational psychology. Her writing and research to date can be viewed on her blog: http://emo.world

Article 8: The Effects of Using Representations in Elementary Mathematics: Meta-Analysis of Research

Dr Andrzej Sokolowski is a researcher and Mathematics and Physics Professor at Lone Star College in Houston. He is an author of several papers on mathematical modeling and STEM education. He recently published a book *Scientific Inquiry in Mathematics, Theory and Practice*.
Email: Andrzej.Sokolowski@lonestar.edu

Mentoring Experiences, Issues, and Concerns in the Student-Teaching Program: Towards a Proposed Mentoring Program in Teacher Education

Susan Galamay-Cachola
Saint Mary's University, Philippines

Ma. Cristeta M. Aduca
Saint Mary's University, Philippines

Federicia C. Calauagan
Saint Mary's University, Philippines

Abstract

Mentoring involves the process of experienced teachers teaching and guiding student-teachers on the different aspects of the teaching-learning process. This study aimed to determine the mentoring experiences of cooperating teachers and student-teachers using quantitative-qualitative design. Survey questionnaires based on Hudson's model were distributed and interviews were conducted among cooperating teachers and student-teachers. Means, standard deviations, t-test for independent samples and paired samples t-test were used to analyze the data. Qualitative responses were analyzed and categorized thematically. Findings indicate that the cooperating teachers perceived they greatly mentored student-teachers in terms of personal attributes, system requirements, pedagogical knowledge, modeling, and feedback which were validated by the student-teachers except in the area of system requirements wherein they were mentored moderately. The study concluded that the cooperating teachers mentored to a great extent the student-teachers. Provision of continuing professional education for cooperating teachers to enrich their skills on mentoring student-teachers and more time for post-conference were recommended.

Keywords: feedback, pedagogical knowledge, personal attributes, modeling, system requirements

Teaching is a complex process which necessitates that teacher preparation programs provide intensive training such as mentoring by expert teachers. Through mentoring, student teachers learn about the teaching process specifically the acquisition of the required basic skills and professional knowledge (Mena, Hennissen, & Loughran, 2017). Student teachers are fielded to laboratory schools as part of the student teachers' training. Student teaching placements are important in preparing student teachers since these field involvements provide authentic and relevant teaching experiences. In addition, these teaching experiences provide student teachers opportunities to learn instructional and class management strategies from mentor teachers (Chizhik, Chizhik, Close, & Gallego, 2017).

However, the realities of classroom teaching present problematic areas in the student teaching program. On one hand, student teachers are under-prepared for actual classroom teaching. The study of Soslau and Raths (2017) presented some problematic aspects of student teaching supervision such as giving feedback, specifically on planning, assessment, and relationship with pupils, among others. On the other hand, some supervisors or cooperating teachers find difficulty in providing evaluative feedback to student teachers, keeping communication channels open, and maintaining positive daily interactions inasmuch as they perform both formative and summative evaluations.

Mentoring has become a crucial component of pre-service field experiences such as student teaching (Bird & Hudson, 2017). Proper and adequate mentoring of student-teachers is vital in the student teaching program inasmuch as experienced mentors provide career and psychosocial support to relatively less experienced protégés – the student-teachers (Menges, 2016; Cakir & Kocabas, 2016). Accordingly, it is mandatory that the cooperating teachers who are tasked to mentor students demonstrate expertise in content and pedagogy, effective communication skills, possession of a positive attitude and a professional demeanor, manifestation of genuine interest in preparing and supporting aspiring teachers, ability to effectively prepare and support aspiring teachers, and willingness to work with other teacher preparation professionals (Gareis & Grant, 2014).

Cooperating teachers provide inspiration to their student-teachers through their dedication to uphold quality instruction which is made possible through relevant teacher education training and programs (Gorozidis & Papaioannou, 2014) to improve their skills and become more proficient. Cooperating teachers who manifest greater efficacy in their role as mentors to student-teachers become more effective instructional models and inspire stronger performances by student teachers. As mentors, cooperating teachers also believed that they benefited from reflecting on their teaching (Aspfors & Fransson, 2015) and sharing their experiences with colleagues (Clarke, Killeavy, & Moloney, 2013).

Crucial to the success of mentoring is the mentor-mentee relationship. Several studies have explored the mentoring experiences that take place in the student teaching program. The studies of Hudson (2016) and Ulvik and Sunde (2013) indicated that a positive mentor–mentee relationship is essential for the mentee's development of teaching practices. Findings revealed that positive relationships required the achievement of trust and respect by sharing information, resources, and expectations and by being professional, enthusiastic, and supportive with collaborative problem-solving. For a positive mentoring relationship to prosper, certain attributes are desired for both mentors and mentees. The study of Hudson and Hudson (2014) indicated that mentors' desirable attributes included enthusiasm, commitment, and resilience and mentors' essential practices comprised planning, preparation, and building a teaching repertoire for mentees. In addition, Hudson (2013) investigated the mentor teachers' expectations of desirable attributes and practices for mentees. Mentees are expected to manifest desirable attributes such as being enthusiastic, personable, committed to children, love learning, open/reflective to feedback, resilient, and taking responsibility for their learning. In terms of desirable practices mentees are expected to plan and prepare for teaching, reflect on their teaching practices, understand school and university policies, know students for differentiated learning, and build a teaching repertoire such as teaching strategies, behavior management, content knowledge, and questioning skills.

Mentor-mentee relationship is also founded on articulation of expectations at the beginning of the mentee's school experiences. Mentees have high expectations of their mentors in terms of supervision and support (Kemmis, Heikkinen, Fransson, Aspfors, & Edwards-Groves, 2014), pedagogical knowledge practices, and meeting teaching standards (Yirci, Karakose, Uygun, & Ozdemir, 2016). Mentors expected their mentees to be risk takers with high levels of professionalism that have students at the center of learning how to teach. As presented by Hudson (2013), the development and provision of positive mentoring relationships are essential to student-teachers' learning. Trust and respect build and sustain mentor-mentee relationship along with mentors' professionalism, open communication, attentive listening and friendly dispositions (Hudson, 2013; Straus, Johnson, Marquez, & Feldman, 2013). Support provided by mentors consisted of providing information for planning, access to resources, and two-way dialoguing with feedback and reflections. Other forms of mentor support also entailed encouraging mentees to get out of their comfort zone and explore and learn new teaching practices.

This study was conceptualized in view of the clamor of student teachers for quality supervision in the student teaching program and the mandate to provide quality education. This study explored the mentoring experiences of the cooperating teachers and student teachers in the areas of personal attributes, systems requirements, pedagogical knowledge, modeling, and feedback as well as their issues and concerns in terms of supervision. It also investigated whether there was significant difference in the extent of mentoring experiences cooperating teachers provided and student-teachers received. Further, the study also explored aspects of mentoring that need to be addressed and program in teacher education that can be crafted to provide support for the professional development and training of cooperating teachers in preparation for more effective mentoring practices towards the student teachers.

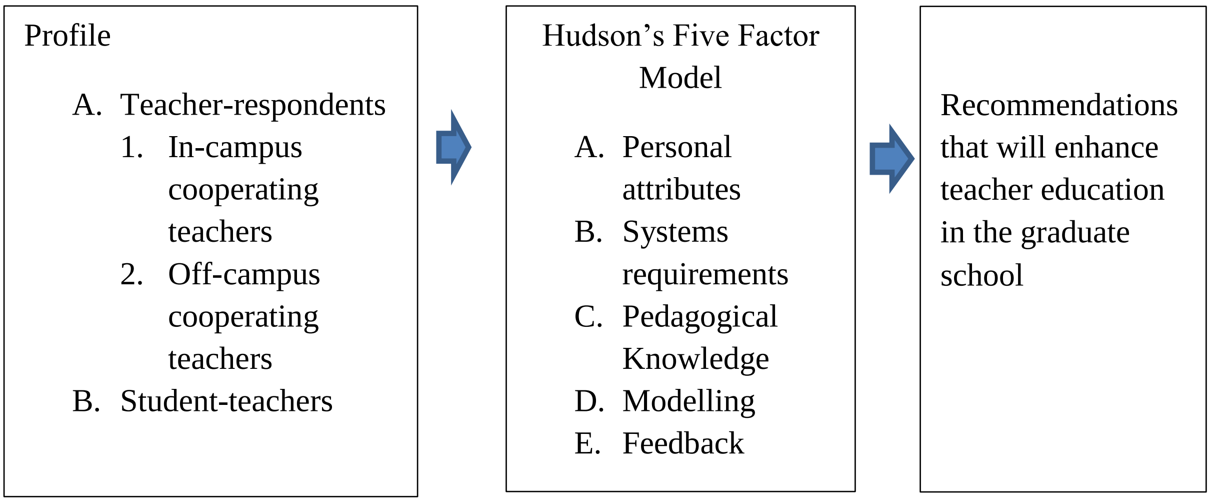

Figure 1. Research paradigm

The model of mentoring suggested by Bird and Hudson (2015) indicates five factors that are linked to mentoring attributes and practices. The first factor refers to mentors' personal attributes which consist of mentors' support of the mentees, ease of communication especially discussion of teaching practices, and active listening to the mentees. The personal attributes of the mentors encourage the mentees to reflect on their pedagogical practices, inspire self-confidence and positive attitudes.

The second factor in mentoring is on systems requirements. Mentors need to communicate that educational systems have requirements such as aims, policies, and curricula. The complexities for executing system requirements may be indicated in the pedagogical knowledge mentors must articulate for effective teaching (Bird & Hudson, 2015).

Pedagogical knowledge, the third factor, indicates that mentors articulate making learning plans for teaching. Mentors need to discuss aspects of the preparation such as use of resources, appropriate teaching strategies, and content knowledge of the mentee. The mentor can assist the mentee in case incidental problems arise during lessons such as managing student behavior inasmuch as the mentor has gained experience on how to deal with various student personality types and behavior traits. The mentor can also assist the mentee on the art of questioning such as formulating question that are of low order thinking or high order thinking. Learning plans follow a certain structure and mentors can discuss the different parts and how these parts are implemented. Mentors can also provide pedagogical knowledge about evaluation of students' learning and explain how it is linked to curriculum, pedagogy, and assessment (Bird & Hudson, 2015).

Modeling as the fourth factor indicates that the mentor's readiness as a teacher can nurture the development of desirable teaching traits in the mentee. Significantly, the teacher-student relationship is vital to the teaching-learning process and establishing a positive relationship with students can demonstrate to the mentee how these behaviors can facilitate learning. The mentor also needs to model proper classroom language appropriate for student learning, instruction (what to do and what not to do), effective teaching, classroom management, hands-on lessons, and well-designed lessons (Bird & Hudson, 2015).

The fifth factor indicates the importance of feedback. Effective mentors communicate expectations and provide guidance to the mentee in terms of reviewing lesson plans, observing the mentee's teaching performance, providing oral and written feedback, and giving further advice on the mentee's evaluation of their teaching and how the mentees establish a learning environment (Bird & Hudson, 2015).

Hudson's model indicates that effective mentoring of practice teachers can reinforce and enhance teaching practices that will contribute to improved student learning. Skillful analysis of practice teachers' teaching performance can have a profound effect on the learning that occurs in the classroom. Because student learning is the primary function of the schools, effective supervision of instruction is very critical. Thus, the pre-service teaching curriculum should include a variety of teaching strategies designed to meet the diverse needs of all students in our complex society.

In these contexts, the mentoring experiences of cooperating teachers and student-teachers were investigated through a survey and structured interview guide questions. The study was conducted to provide insights into cooperating teachers' role as mentors. Likewise, areas for development in terms of supervision and instruction were also determined. Findings served as basis in drafting a program that addressed the needs of cooperating teachers and enhanced the teacher education program. These experiences provided insights on how mentors can make the practice teaching experience of student-teachers meaningful and help them acquire and develop pedagogical knowledge, skills and values essential in their formation as future teachers in accordance with the requirements of the National Competency-Based Teacher Standards (NCBTS).

Methodology

This study used quantitative-qualitative design. The quantitative design was used to determine the extent of mentoring cooperating teachers provided to their student-teachers. It also investigated the extent of mentoring received by student-teachers from their cooperating teachers. In the quantitative design, survey questionnaires were distributed to the respondents. This method was used to find existing realities that can provide essential information for the study. Qualitative design, specifically the use of interview, was also employed to surface responses that enriched the numerical data gathered in the survey. The study was conducted at Saint Mary's University, Bayombong, Nueva Vizcaya (SMU), and the public schools in Nueva Vizcaya where the student-teachers were deployed in theiro-campus teaching experience. SMU is one of the five Congregatio Immaculati Cordis Mariae (CICM) schools in the Philippines founded in 1928 and earned its university status in 1994.

The tools that were used in gathering the data were a researcher-designed questionnaire based on Hudson's five factor model and structured interview guide questions constructed by the researchers. There were two sets of questionnaire and interview guide questions answered by the respondents. The first set was for cooperating teachers and the second set was for the student teachers. The Cronbach alpha of .956 indicated that the survey questionnaire had very high reliability. The Likert scale used in the interpretation of the data was as follows: 1.00-1.49 (Not at all); 1.50-2.49 (Little extent); 2.50-3.49 (Moderate extent); 3.50-4.00 (Great extent).

The study used population sampling wherein all of the 71 student-teachers who were enrolled in the Student Teaching Program in the school year 2016-2017 were respondents in order to obtain a holistic picture of the study. Teacher-respondents were those who were assigned student teachers to mentor. There were 61 Off-campus cooperating teachers and 30 On-campus cooperating teachers.

To determine the extent of mentoring provided by the cooperating teachers and received by the student-teachers, means, medians and standard deviations were used. To determine the significant difference in the extent of mentoring provided by the off-campus and in-campus teachers, t-test for independent samples was used. To determine the significant difference in the extent of mentoring received by the student-teachers, paired samples t-test was used. Qualitative responses from the written interview were used to support the qualitative data. Qualitative responses were also analyzed and categorized thematically.

Results and Discussion

Extent of Mentoring Practices Cooperating Teachers Provide to Student Teachers

Table 1 presents the extent of mentoring practices cooperating teachers provided to student teachers in terms of personal attributes. As indicated by the overall mean (Off-campus=3.81; In-campus= 3.85), the cooperating teachers perceived that they greatly mentored the student-teachers in terms of their personal attributes. The off-campus cooperating teachers demonstrated high willingness to model positive values while the cooperating teachers in the on-campus displayed commitment to mentor the student-teachers and passion for teaching to a large extent. Verbatim responses from the cooperating teachers indicated that they had "always been positive in teaching". The cooperating teachers also indicated the need for the provision of "orientation about good personal attitude" such as "always be on time; be flexible" and making themselves "available for student-teachers" and "promote comfort" and "help them gain confidence in teaching" by "treating them with respect, mentoring by coaching, lending, motivating, inspiring them to teach". In addition, an in-campus cooperating teacher indicated that she used Appreciation, Time and Encouragement (ATE). She pointed that "student teachers learn best when they feel that their cooperating teachers help them have their knowledge, skills and values as future teachers".

Table 1. Extent of mentoring practices cooperating teachers provide to student teachers in terms of personal attributes

In my mentoring with student-teachers, I demonstrate that I …	Cooperating Teachers Off-campus (N=61)			Cooperating Teachers On-campus (N=30)		
	Mean	SD	QD	Mean	SD	QD
1. am flexible	3.74	0.44	Great	3.67	0.54	Great
2. am open-minded	3.84	0.37	Great	3.77	0.43	Great
3. foster confidence by providing opportunities for friendship	3.74	0.44	Great	3.77	0.43	Great
4. promote comfort and confidence and help student teachers feel comfortable in teaching	3.85	0.35	Great	3.97	0.18	Great
5. make myself available for my student-teachers	3.84	0.37	Great	3.90	0.30	Great
6. show willingness to model positive values	**3.92**	0.27	Great	3.83	0.37	Great
7.am committed to mentor my student-teaches	3.74	0.44	Great	**3.97**	0.18	Great
8. am passionate in teaching	3.85	0.35	Great	**3.97**	0.18	Great
Overall Mean	**3.81**	0.28	Great	**3.85**	0.23	Great

Table 2. Extent of mentoring practices cooperating teachers provided to student teachers in terms of system requirements

	Cooperating Teachers Off-campus (N=61)			Cooperating Teachers On-campus (N=30)		
In my mentoring with student-teachers, I…	Mean	SD	QD	Mean	SD	QD
1.orient student teachers about school requirements	3.56	0.53	Great	3.63	0.66	Great
2.provide guidelines for the accomplishment of school records/forms	3.51	0.56	Great	3.17	1.05	Moderate
3.give instruction about grading systems and school policies	3.59	0.49	Great	3.33	0.84	Moderate
Overall Mean	3.55	0.43	Great	3.38	0.76	Moderate

Table 2 shows the extent of mentoring practices cooperating teachers provided to student teachers in terms of system requirements. The overall mean (Off-campus=3.55; In-campus=3.38) indicates that the off-campus cooperating teachers greatly mentored the student-teachers while the in-campus teachers only to a moderate extent. The off-campus teachers greatly mentored student-teachers on orienting student-teachers about school requirements, provided guidelines for the accomplishment of school records/forms and gave instruction about grading systems and school policies while the in-campus teachers did these only to a moderate extent. The interview conducted with cooperating teachers showed verbatim comments indicating that they mentored the student-teachers in matters concerning "orientation on school requirements" and "…the policies of the school" to a high degree.

Table 3.Extent of mentoring practices cooperating teachers provided to student teachers in terms of pedagogical knowledge

	Cooperating Teachers Off-campus (N=61)			Cooperating Teachers On-campus (N=30)		
In my mentoring with student-teachers, I …	Mean	SD	QD	Mean	SD	QD
1.coach via sharing ideas or telling information	3.69	0.46	Great	3.80	0.40	Great
2.plan collaboratively with my student-teachers on learning plans	3.7	0.61	Great	3.73	0.45	Great
3.provide essential resources for teaching	**3.51**	0.59	Great	**3.73**	0.45	Great
4.share my vision/ principles of teaching	3.57	0.59	Great	3.77	0.50	Great
5.share my knowledge about	3.66	0.60	Great	3.67	0.54	Great
a. Problem-solving	3.61	0.66	Great	3.63	0.55	Great
b. Timetabling	3.72	0.55	Great	3.70	0.46	Great
c. Assessment	3.77	0.61	Great	3.83	0.37	Great
Overall Mean	**3.65**	0.44	Great	**3.73**	0.4	Great

Table 3 presents the extent of mentoring practices cooperating teachers provided to student teachers in terms of pedagogical knowledge. The overall mean (Off-campus =3.65; In-campus= 3.73) shows that the in-campus teachers mentored more the student-teachers in their sharing their pedagogical knowledge. The cooperating teachers also greatly mentored the student-teachers in their sharing of knowledge about assessment. Cooperating teachers believed in the importance of mentoring student teachers on matters concerning pedagogical knowledge stating that "if student-teachers' schedule will be given earlier, they will be given more time for close supervision". Moreover, the cooperating teachers believed that student-teachers should be given "ample time to prepare and teach them to have time table" and that "a schedule that will work should be given so that student-teachers and cooperating teachers can really collaborate".

Table 4 shows the extent of mentoring practices cooperating teachers provided to student teachers in terms of modeling. The overall mean (Off-campus= 3.74; In-campus=3.93) indicates that the off-campus and in-campus teachers greatly mentored the student-teachers in terms of modeling. The off-campus showed high enthusiasm in teaching (Mean=3.80) while the in-campus teachers greatly demonstrated enthusiasm (Mean=3.97) and effective classroom management. Verbatim comments from cooperating teachers pointed out that they did "coach and share ideas in choosing appropriate strategy", "share their vision of teaching" because they believed that "experiential teaching is lasting and more meaningful". In addition, a cooperating teacher also emphasized to her student-teacher that "all were provided to mold him as good teacher – important information and best strategies". Still, another cooperating teacher shared that teaching is a vocation as indicated in her statement, "I believe that teaching is not only a job, it's a ministry". They indicated that they modeled to student-teachers their "… adoption of reflective teaching approach".

Table 4. Extent of mentoring practices cooperating teachers provided to student teachers in terms of modeling

	Cooperating Teachers Off-campus (N=61)			Cooperating Teachers On-campus (N=30)		
In my mentoring with student-teachers, I …	Mean	SD	QD	Mean	SD	QD
1.demonstrate how to teach the subject matter	3.67	0.65	Great	3.93	0.25	Great
2.show enthusiasm	3.80	0.60	Great	3.97	0.18	Great
3.demonstrate effective classroom management	3.75	0.62	Great	3.97	0.18	Great
4.demonstrate rapport with students	3.74	0.63	Great	3.87	0.34	Great
Overall Mean	**3.74**	0.59	Great	**3.93**	0.18	Great

Table 5. Extent of mentoring practices cooperating teachers provided to student teachers in terms of feedback

	Cooperating Teachers Off-campus (N=61)			Cooperating Teachers On-campus (N=30)		
In my mentoring with student-teachers, I …	Mean	SD	QD	Mean	SD	QD
1.provide positive feedback	3.64	0.65	Great	3.87	0.34	Great
2.encourage students to practice reflective teaching	3.61	0.69	Great	3.83	0.37	Great
Overall Mean	3.62	0.66	Great	3.85	0.35	Great

Table 5 presents the extent of mentoring practices cooperating teachers provided to student teachers in terms of feedback. The overall mean (Off-campus=3.62; In-campus=0.662) indicates that the cooperating teachers greatly mentored the student-teachers in terms of providing feedback and encouraging students to practice reflective teaching. The cooperating teachers believed that they have mentored the student teachers and that they have provided "…positive feedback and suggestions for improvement" which "…provides actionable information" "…to develop the confidence of student-teachers".

Table 6 shows the difference in the extent of mentoring practices cooperating teachers provided to student teachers. Among the five factors, modeling (t=-2.31; p=0.023) and feedback (t=-2.136; p=0.035) yielded significant results. This indicates that the in-campus teachers perceived that they mentored greatly the student-teachers in terms of modeling and giving feedback than the off-campus teachers and the difference is significant.

Table 6. Difference in the Extent of Mentoring Practices Cooperating Teachers Provided to Student Teachers

Independent Samples Test						
		Levene's Test for Equality of Variances				
		F	Sig.	t	df	Sig. (2-tailed)
1. Personal Attributes	Equal variances assumed	0.302	0.584	-0.683	89	0.496
2.System Requirements	Equal variances not assumed	21.856	0.000	1.156	38.402	0.255
3. Pedagogical Knowledge	Equal variances assumed	0.041	0.84	-0.825	89	0.412
4. Modeling	Equal variances not assumed	7.568	0.007	-2.31	79.702	**0.023**
5. Feedback	Equal variances not assumed	9.556	0.003	-2.136	88.427	**0.035**

Extent of mentoring practices student–teachers received from cooperating teachers

Table 7 presents the extent of mentoring practices student–teachers received from cooperating teachers in terms of personal attributes. As indicated by the overall mean (Off-campus=3.60; In-campus=3.72), the student-teachers were mentored greatly by the cooperating teachers in terms of their display of personal attributes. The off-campus teachers greatly mentored on showing passion in teaching (Mean=3.70) while the in-campus teachers demonstrated willingness to model positive values (Mean=3.83). The student teachers found their mentors conscientious in their task of mentoring them through their own personal witnessing as expressed in their verbatim comments to "… approach them and talk about their performance in teaching" to "share experiences that they can adopt". Moreover, the student-teachers were mentored greatly by cooperating teachers who extended their "moral support", who were "kind enough to guide us in every teaching" and were "very kind and willing to share their experiences and knowledge" and showed "enthusiasm" in their teaching.

Table 7. Extent of mentoring practices student–teachers received from cooperating teachers in terms of personal attributes

	Cooperating Teachers Off-campus			Cooperating Teachers On-campus		
Statements	Mean	SD	QD	Mean	SD	QD
1.My cooperating teacher demonstrates flexibility	3.54	0.62	Great	3.58	0.62	Great
2. My cooperating teacher demonstrates open-mindedness	3.68	0.55	Great	3.76	0.52	Great
3. My cooperating teacher fosters confidence by providing opportunities for friendship	3.56	0.60	Great	3.70	0.61	Great
4. My cooperating teacher promotes comfort and confidence and help student teachers feel comfortable in teaching	3.55	0.65	Great	3.73	0.58	Great
5. My cooperating teacher makes herself available for mentoring	3.52	0.67	Great	3.73	0.53	Great
6. My cooperating teacher demonstrates willingness to model positive values	3.73	0.53	Great	3.83	0.37	Great
7. My cooperating teacher demonstrates commitment to mentoring	3.58	0.69	Great	3.69	0.57	Great
8. My cooperating teacher shows passion in teaching.	3.70	0.57	Great	3.75	0.52	Great
Overall Mean	3.60	0.47	Great	3.72	0.46	Great

Table 8. Extent of mentoring practices student–teachers received from cooperating teachers in terms of system requirements

	Cooperating Teachers Off-campus			Cooperating Teachers On-campus		
My cooperating teacher	Mean	SD	QD	Mean	SD	QD
1.orient us about school requirements	3.32	0.67	Moderate	3.35	0.65	Moderate
2.provide guidelines for the accomplishment of school records/forms	3.27	0.69	Moderate	3.41	0.68	Moderate
3.give instruction about grading systems and school policies	3.18	0.76	Moderate	3.29	0.74	Moderate
Overall Mean	3.26	0.63	Moderate	3.35	0.63	Moderate

Table 8 presents the extent of mentoring practices student – teachers received from cooperating teachers in terms of system requirements. As shown in the overall mean (Off-campus=3.26; In-campus=3.35), student teachers believed they were mentored on system requirements only to a moderate extent. These system requirements consisted of orientation about school requirements, provision of guidelines for the accomplishment of school records/forms, and giving of instruction about grading systems and school policies. Verbatim comments by the student-teachers stated they were mentored on "how to make standard lesson log of SMU-HS" and "how to make Department of Education Learning Plans".

Table 9. Extent of mentoring practices student–teachers received from cooperating teachers in terms of pedagogical knowledge

	Cooperating Teachers Off-campus			Cooperating Teachers On-campus		
My cooperating teacher	Mean	SD	QD	Mean	SD	QD
1. coaches via sharing ideas or telling information	3.56	0.60	Great	3.65	0.65	Great
2. plan collaboratively with student-teachers on learning plans	3.52	0.60	Great	3.55	0.71	Great
3. provide essential resources for teaching	3.35	0.61	Moderate	3.46	0.69	Moderate
4. share his/her vision and principles of teaching	3.34	0.75	Moderate	3.46	0.73	Moderate
5. share his/her knowledge about:						
a. Problem-solving	3.17	0.77	Moderate	3.48	0.69	Moderate
b. Timetabling	3.42	0.66	Moderate	3.62	0.57	Great
c. Assessment	3.55	0.60	Great	3.61	0.64	Great
Overall Mean	3.39	0.51	Moderate	3.53	0.57	Great

Table 9 shows the extent of mentoring practices student-teachers received from cooperating teachers in terms of pedagogical knowledge. The overall mean shows that the student-teachers were mentored on pedagogical knowledge by the in-campus teachers to a great extent (Mean=3.53) and only to a moderate extent by the off-campus teachers (Mean= 3.39). The student-teachers considered they were greatly mentored by the off-campus and in-campus teachers through their sharing of ideas or telling information. However, they were least mentored by the off-campus teachers on solving problems and least mentored by the in-campus teachers on provision of essential resources for teaching and sharing their vision and principles of teaching, although still to a moderate extent. The student-teachers pointed out that they were greatly mentored by their cooperating teachers through their assistance and support on how to "make lesson logs from syllabus". The student-teachers were also helped by their cooperating teachers who "gave advice and suggestions in teaching strategies and classroom management", demonstrated "questioning techniques", provided "lists of strategies in summarizing the lesson and ways in purposeful closure", extended "materials needed, comfort and ideas in delivering lesson" shared "…video clips on how to teach 21st century learners" and "introduced several methods in conducting activities".

Table 10 shows the extent of mentoring practices student–teachers received from cooperating teachers in terms of modeling. The overall mean (Off-campus=3.50; In-campus = 3.59) indicates that the student-teachers were mentored to a great extent by the cooperating teachers in terms of modeling. The student-teachers were greatly mentored by the cooperating teachers in terms of modeling enthusiasm in teaching and the least area of mentoring was on how to teach the subject matter, although still to a moderate extent. The student-teachers believed they were greatly mentored by their cooperating teachers who demonstrated “how to introduce lesson in an engaging way”, “how to teach subject matter”, “how to establish rapport with students”, “how to handle class when there is group activity” and “how to conclude the lesson”.

Table 10. Extent of mentoring practices student-teachers received from cooperating teachers in terms of modeling

	Cooperating Teachers Off-campus			Cooperating Teachers On-campus		
My cooperating teacher	Mean	SD	QD	Mean	SD	QD
1.demonstrates how to teach the subject matter	3.42	0.64	Moderate	3.54	0.75	Great
2.shows enthusiasm	3.59	0.64	Great	3.65	0.61	Great
3.demonstrate effective classroom management	3.52	0.62	Great	3.59	0.64	Great
4.demonstrate rapport with students	3.48	0.67	Moderate	3.62	0.64	Great
Overall Mean	3.50	0.53	Great	3.59	0.56	Great

Table 11. Extent of mentoring practices student-teachers received from cooperating teachers in terms of feedback

	Cooperating Teachers Off-campus			Cooperating Teachers On-campus		
My cooperating teacher	Mean	SD	QD	Mean	SD	QD
1.provides positive feedback	3.59	0.57	Great	3.63	0.56	Great
2.encourages students to practice reflective teaching	3.59	0.62	Great	3.62	0.64	Great
Overall Mean	3.59	0.56	Great	3.62	0.55	Great

Table 11 shows the extent of mentoring practices student-teachers received from cooperating teachers in terms of feedback. As presented in the overall mean (Off-campus=3.59; In-campus = 3.62), the student-teachers were mentored by the cooperating teachers in both campuses in terms of providing feedback and encouraging students to practice reflective teaching to a great extent. The student-teachers agreed they were greatly mentored by their cooperating teachers who “finds time to tell feedback about strengths and quality of my teaching” during the “post-conference” wherein they were provided “feedback if their strategy is effective”. The student-teachers were greatly helped by the cooperating teachers because “in the post conference, they told us about our weaknesses and how to improve our teaching methods”. The student-teachers were also mentored on the importance of “providing nice and proper feedback to students” and the “use of appropriate activities and instructional materials” in teaching.

Table 12 shows the difference in the extent of mentoring practices student teachers received from cooperating teachers. The results yielded no significant difference. This indicates that the mentoring the student-teachers received from the cooperating teachers were statistically the same.

Table 12. Difference in the extent of mentoring practices student-teachers received from cooperating teachers

Paired Samples Statistics						
		Mean	SD	t	df	Sig. (2-tailed)
1. Personal attributes	Off-campus	3.60	0.479	-1.466	70	0.147
	In-campus	3.72	0.462			
2. System requirements	Off-campus	3.26	0.632	-0.89	70	0.377
	In-campus	3.35	0.639			
3. Pedagogical knowledge	Off-campus	3.39	0.519	-1.583	70	0.118
	In-campus	3.53	0.571			
4. Modeling	Off-campus	3.50	0.537	-1.043	70	0.301
	In-campus	3.59	0.562			
5. Feedback	Off-campus	3.59	0.568	-0.371	70	0.711
	In-campus	3.62	0.552			

Discussion and Limitations of the Study

The mentors' task of providing feedback to student teachers is crucial to the mentoring process. Mentors have the responsibility to assist their mentee in terms of their career and provide advice, support, and feedback and "be a sounding board for the mentee" (Straus et al, 2013). The cooperating teachers had done a great job in mentoring the student-teachers especially in their witnessing of personal qualities that student teachers should imbibe as future teachers. Effective mentors must be altruistic, honest, trustworthy, and active listeners.

The mentoring cooperating teachers provided to student teachers was indeed significant inasmuch as student teachers found difficulty in accomplishing school system requirements. The importance of an advisor or a mentor in guiding inexperienced teachers especially in their performance of bureaucratic duties and management of educational activity should not be underestimated (Yirci et al, 2016). This implies that cooperating teachers realize the importance of mentoring students and sharing their expertise on content knowledge as well as strategies. It also indicates that cooperating teachers need to practice reflective approach in teaching so that they could better mentor the student teachers on what teaching strategies work for a more effective teaching learning situation (Aspfors & Fransson, 2015).

Similarly, the cooperating teachers demonstrated commitment to their mentoring task of teaching through practice. Cooperating teachers who demonstrated and modeled content knowledge and strategies enhanced the professional development of student teachers as well as improved their student teachers' teaching methods and skills (Liu, Tsai, & Huang, 2015). The findings imply that the cooperating teachers had provided more mentoring to student teachers in terms of modeling specifically demonstrating how to teach the subject matter, showing enthusiasm, demonstrating effective classroom management, and establishing rapport with students as well as providing positive feedback and encouraging students to practice reflective teaching.

The study of Sempowicz and Hudson (2012) also affirmed that mentor-mentee's personal attributes had significant impact on their mentoring relationship which affected the effectiveness of the mentors' feedback and the mentees' abilities to critically reflect on their practices. Student teachers who have positive relationships with their mentors are more likely to employ university-taught methods in their classrooms, take their supervisors' advice, and view their supervisor as very knowledgeable regarding content, methods, and students in the "real" classroom (Asplin & Marks, 2013).

As mentees, student teachers need to learn the teaching strategy of timing within the lesson structure to promote student interest in learning. Mentors emphasized the need to prepare and manage resources and aids as well as the ability to solve problems in the classroom such as changing strategies whenever necessary (Hudson, 2013). In addition, student teachers need to be provided with feedback and assessment on their student teaching. Student teachers, in return, should be open to feedback, be active listeners, and be respectful of their mentor's input and time (Straus et al, 2013).

This study is limited to determining the mentoring experiences of the cooperating teachers and student teachers as indicated in the five aspects of mentoring presented by Hudson. The study focused only on surfacing the mentoring experiences in general and did not explore the cultural practices between mentor and mentees. Web-based learning and e-mentoring may also be explored in future studies to strengthen the mentoring process.

Aspects Needing to be Addressed

Reinforcing personal attributes through open communication, active listening, and self-learning

The responses of the participants to the structured interview guide questions yielded five major themes relative to the need for mentoring. The first theme is reinforcing personal attributes through open communication, active listening and self-learning which concurs with existing studies on the beneficial effects of mentoring in the respondents' formation as prospective teachers. The quality of the cooperating teachers' relationship with practice teachers has direct impact on how they enact principles of practice. The positive relationship and open communication with their cooperating teachers inspires them to reflect on their pedagogical practices and develop their self-confidence and positive attitudes. Mentor-mentee's personal attributes had significant impact on their mentoring relationship which affected the effectiveness of the mentors' feedback and the mentees' abilities to critically reflect on their practices. In this theme, mentoring is the process which supports learning development and improves performance of an individual. It manifests through the mentors' treating the practice teachers with respect, having an open and motivational consultation, showing moral and sometimes financial support, sharing ideas and experiences, providing comfort and boosting one's confidence and providing time to listen (Hudson, 2016; Hudson & Hudson, 2014; Kemmis et al, 2014; Hudson, 2013; Straus et al, 2013; Ulvik & Sunde, 2013; Sempowicz & Hudson, 2012).

Providing intensive orientation on educational goals, aims, policies and curricula

The second theme is focused on providing intensive orientation on educational goals, aims, policies, and curricula. Pre-service teachers need to acquire an understanding of the expectations, components, goals, and challenges of the student teaching experience. Mentors need to communicate that educational system has requirements such as aims, policies, and curricula. The complexities for executing system requirements may be indicated in the pedagogical knowledge mentors must articulate for effective teaching (Aspfors & Fransson, 2015; Asplin & Marks, 2013; Gareis & Grant, 2014; Gorozidis & Papaioannou, 2014; Hobson, Harris, Buckley Manley, & Smith, 2012). Most of the respondents acquired knowledge about the school assignments and policies; Department of Education Orders, policies and requirements, and the what, why and how of the K to 12 curriculum.

Enhancing pedagogical knowledge in teaching

Enhancing pedagogical knowledge in teaching is another theme that emerged from the study. Mentoring is a deliberate pairing of a more skilled or experienced person with a lesser skilled or experienced one with agreed-upon goals. The lesser skilled person is assisted to grow and develop specific competencies (Menges, 2016; Cakir & Kocabas, 2016). This includes the development of pedagogical knowledge practices such as planning, preparation, teaching strategies, questioning skills, assessment and how these practices influence the mentee's practice teaching. Willing, capable, and compatible mentors who possess varied expertise provide richer and more dynamic mentoring experiences (Gareis & Grant, 2014; Hudson, 2012).

Nurturing the development of desirable teaching practices through modeling

The next theme is nurturing the development of desirable teaching practices through modeling. Experienced teachers can provide help by providing strategies they developed. Moreover, student teachers can be guided in the acquisition of knowledge and skills by assigned mentors who model pedagogical practices Hudson's (2012). Hudson's study (2007) revealed that mentors modeled teaching and classroom management, had a good rapport with students, and enthusiasm. The theme underscores the importance of mentoring of cooperating teachers who have a repertoire of effective pedagogical practices and up-to-date curriculum and professional knowledge to better assist student teachers in pre-service education (Yirci et al, 2016; Kemmis et al, 2014).

Communicating achievable expectations and providing constructive feedbacks

The last theme, which is communicating achievable expectations and providing constructive feedback, reveals similar insights from the participants. This supports one of the findings of Sempowicz and Hudson (2012) that "mentors expressed expectations for teaching, modeled reflective practices to their mentees, and provided time and opportunities for mentoring which would influence the mentees' reflective practices and their pedagogical development." The importance of communicating expectations and giving regular feedback on student teachers' assessment in their practice teaching are also important concerns cooperating teachers should provide. Providing professional development for the cooperating or mentor teacher in preparation for accommodating a student intern is significant. Student interns must have mentors who are skilled and experienced in mentoring and who can nurture positive development toward becoming an effective teacher. Moreover, Teacher Education Institutions need to ensure that mentor teachers are adequately prepared to model effective strategies to facilitate the practice teaching experience. The study also reiterated that mentor teachers understand their role in facilitating the internship experience because their roles are critical to the development of the student intern (Gareis & Grant, 2014).

Conclusions

In the light of the findings, the following conclusions are drawn:

1. The cooperating teachers mentored to a great extent the student teachers in terms of personal attributes, pedagogical knowledge, modelling, and feedback.
2. The student teachers need more intensive mentoring on the area of system requirements.

Recommendations

The following recommendations are presented:

1. Cooperating teachers should undergo continuing professional education specifically in terms of mentoring student-teachers along the domains mentioned. A course specifically on supervision and instruction be included in the curriculum to further strengthen the cooperating teachers' mentoring practices and skills.
2. More time for post-conference between the cooperating teachers and student-teachers be provided to discuss supervisory concerns and address further mentoring needs.

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Corresponding Author: Susan Galamay-Cachola
Contact email: susangcachola@gmail.com

Work-Related Factors as Determinants of Self-efficacy and Resilience among Selected Filipino Child Development Workers

Katherine del Rosario
University of the Philippines Los Baños, Philippines

Nephtaly Joel Botor
University of the Philippines Los Baños, Philippines

Jewely Jean Padilla
University of the Philippines Los Baños, Philippines

Aida Escobin
University of the Philippines Los Baños, Philippines

Daisy Pelegrina
University of the Philippines Los Baños, Philippines

Abstract

This descriptive associative study focused on work-related factors as determinants of self-efficacy and resilience among 58 purposively-sampled Child Development Workers (CDWs). It specifically aims to profile the CDWs based on various work-related variables, to determine their psychosocial needs, resources, levels of self-efficacy and resilience, and to verify the association and relationship of these variables in relation to self-efficacy and resilience. A questionnaire, comprised of questions on perceived needs and resources and work-related aspects, a modified version of Bandura's (2006) Teacher Self-Efficacy Scale, and Smith et al.'s (2008) Brief Resilience Scale, were group administered to the participants. Thereafter, results were analyzed using descriptive and correlation statistics. Results showed that respondents were divided almost equally between the low- and high-scoring groups in both self-efficacy and resilience. Notably, respondents' resilience and self-efficacy mean scores were relatively higher than the expected average score. Correlation further revealed moderate positive relationship between self-efficacy and resilience ($r = 0.333$). In terms of work-related factors, many of those with high self-efficacy and high resilience scores reported also having: (a) supportive barangay officials, (b) cooperative day care children's parents, (c) satisfaction with pupils, (d) job satisfaction, and (e) life satisfaction in general. As a conclusion, the majority of the 58 selected CDWs reported satisfaction in work-related factors related to the children they cater to, and also work and life in general. In addition, CDWs who had high scores in self-efficacy and resilience reported having support, cooperation and satisfaction.

Keywords: self-efficacy, resilience, child development worker, early childhood care and development

Introduction

Early childhood is a crucial stage primarily because of the rapid development in major developmental domains: physical, cognitive, and socio-emotional, among others. It is a sensitive period of limited duration in which the brain is highly plastic and greatly influenced by experience (Knudsen, 2004). It is also believed to be at this stage that stimulation provided to children within this period will have long lasting effects on learning and behavior.

The crucial nature of early childhood underscores the role played by significant persons involved in child rearing. Among these are the Child Development Workers (CDWs). More commonly known as Day Care Workers (DCWs), CDWs play a significant role in the delivery of early childhood care and development services. They are tasked to supervise the Day Care Centers (DCCs) in every barangay, while being also called to assist in other community affairs, e.g., disaster response (Quismorio, 2014).

Early childhood care and development (ECCD) service providers, particularly Day Care Workers, aptly referred to as Child Development Workers as promulgated in the Early Years Act of 2013 (Philippine Congress, 2012), are key players in holistically addressing the needs of the Filipino child, especially the very young. It is, therefore, necessary to understand the issues relevant to their life and work as child care providers so that support and interventions can be designed and implemented, geared towards enabling them to optimally function in a demanding working environment and empowering them to develop as individuals and professionals in the childcare profession. Unfortunately, there has not been extensive research about CDWs in the Philippines. Empirical investigations on the plight of Filipino CDWs are available, albeit scant, including Abulon's (2013) survey on the status of barangay Day Care Centers in the country, Cadosales' (2011) study on teaching needs of Day Care Workers), and Reyes' (1996) analysis of variables influencing the implementation of day care policy in one of Philippine regions.

Day care centers in the Philippines, unlike in Western countries, have a quite different identity. While in most countries the day care is nothing more than a venue in which working parents can temporarily enroll their children to be supervised while away for work, in the Philippines, the increasing number of day care centers manifests the country's commitment to promoting early childhood education (Abulon, 2013). There are almost 33,000 day care centers in the country (Quismorio, 2014), under the supervision of the Department of Social Welfare and Development (DSWD), which are manned by CDWs. Apart from their identity as learning venues for very young children, the DCCs are also a platform for other social services as health, nutrition and safety. This only underscores the multiple and quintessential responsibilities taken by the CDW.

Unfortunately, while the role of CDWs in the community is apparent and significant, there are only a few available studies involving or pertaining them (Abulon, 2013; Cadosales, 2011; Elarco, 2014). The present study envisioned contributing to the discussion on the issues and concerns faced by CDWs in the country. It desired to contribute to the literature on child development profession in the Philippines by exploring dimensions of CDWs' experiences in the work place. On one hand, it recognized the necessity to look into factors that may promote or hinder CDWs' tasks as ECCD service providers. On the other hand, it found meaning in seeing how child care professionals perceive their ability to influence their working environment, more so, how capable they are in responding to adversities in the workplace.

With these premises, the study paid attention to two pivotal constructs: self-efficacy and resilience.

Self-efficacy, which pertains to “beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments” (Bandura, 1977, p. 3), is deemed as a formidable predictor of behavior (Bandura, 1997, as cited in Henson, Kogan & Vacha-Haase, 2001). It has been widely researched in the field of education, more specifically as the context-specific construct *teacher self-efficacy*. Defined as “the degree to which teachers believed the environment could be controlled” (Gibson & Dembo, 1984, p. 570), teacher self-efficacy is deemed as “self-regulatory” and as influential to teacher behavior and performance (Gavora, 2010, p. 17). Pre-school teachers who reported high self-efficacy are found to have planning skills, be more enthusiasm in their teaching endeavors, and to be highly innovative, and creative (Kihoro1i & Bunyi, 2017).

In the context of early childhood care and development, self-efficacy has been found to associate with variables such as child care providers’ desire to stay in the profession, especially when paired with job satisfaction and supervisor support (Chen & Scannapieco, 2010) and job satisfaction and burnout (Skaalvik, E.M. and Skaalvik, S., 2010). It has also been associated with children’s learning outcomes as they learn language (Guo, Piasta, Justice, & Kaderavek, 2010) and with mothers’ psychological outcomes as they balance responsibilities at work and in child rearing (Ozer, 1995). Reciprocally, self-efficacy among childcare providers is influenced by professional experience, perception of collaboration, and children’s engagement (Guo, Justice, Sawyer, & Tompkins, 2011), as well as professional development (Muñez, Bautista, Khiu, Keh, & Bull, 2017), among others. Likewise, self-efficacy level is mediated by the nature of relationship between the parent and the early childhood educator (Chung, Marvin, & Churchill, 2005). In the Philippines, where CDW’s also act as learning facilitators (United Nations Educational, Scientific and Cultural Organization[UNESCO], 2007), contextualizing teacher self-efficacy as applied in the day care situation is fitting.

Resilience is another variable gleaned as essential among professionals working with very young children. This term has been diversely defined and used in various disciplines, but the most basic of its definitions, which was adapted in the context of this study, is that it pertains to people’s “ability to bounce back and recover from stress…and return to previous level of psychologically healthy functioning” (Boyle, et al. 2014, p. 301, citing Carver, 1998, and Smith et al., 2008 and). Considering the multifold function of the CDW and the arduous nature of the child care profession (Levy & Poertner, 2014), exploring DCWs’ resilience is substantial in discovering their needs, concerns and professional satisfaction amidst a stressful work environment (Hegney, Rees, Elay, Osseiran-Moisson, & Francis , 2015). In the context of child care profession, a study by Bouillet, Ivanec and Miljević-Riđički (2014), revealed that, at the average, child care professionals, that is, child care educators, rated themselves as having high levels of resilience. The same authors further found that those who perceived being highly resilient also evaluated themselves as capable of fostering resilience among children. Resilience was found to be quantitatively associated with life satisfaction (Özbey, Büyüktanir, & Türkoglu, 2014), hope and positive behaviors (Hsing-Ming & Mi-Tao, 2008); and, qualitatively, with teachers’ agency, freedom, hope and trust (Sumsion, 2004). In turn, supportive working environment (Bouillet et al., 2014) and capacity building activities such as training (Hraha, 2012) were found to be promoters of resilience.

By and large, it can be gathered from the brief review of empirical findings that there are interactions between self-efficacy and resilience, and other work-related factors. The present study, with the goal of augmenting gaps in understanding the experiences of CDWs in the country, explored the profile of selected Filipino CDWs in terms of work-related factors deemed as reciprocal determinants of efficacy and resilience among childcare professionals and illustrated the nature of associations between and among self-efficacy, resilience, and these work-related factors. Specifically, it attempted to answer the following research questions:

1. What is the profile of the selected CDWs in terms of perceived barangay support, perceived parental cooperation; and satisfaction about the physical workplace, the children they cater to, their job, and their life in general?
2. What are the psychosocial needs and resources of the CDWs?
3. What are the levels of self-efficacy, its subscales, and resilience among the selected CDWs?
4. How do work-related variables associate with self-efficacy and resilience?
5. What is the nature of relationship between self-efficacy and its subscales, and resilience?

By answering these research questions, the study hopes to contribute to the scant literature on day care in the Philippines and to provide insights towards the development and implementation of initiatives to empower and build capacities of CDWs.

Methods

Research Design

The study employed descriptive associative method to depict the profile of work-related factors, levels of perceived self-efficacy and resilience; and, the nature of associations among the study variables.

Study Participants

Fifty-eight (58) CDWs who were participants to a capacity building program for DCWs were purposively selected as respondents in this study.

Scope and limitations

This study was only limited to CDWs from selected areas in Southern Tagalog. It only focused on the respondents' perceived self-efficacy and resilience in relation to their work experiences. Since the sample was not randomly selected, correlation coefficients were used as descriptive statistics.

Measures

The study used a questionnaire consisting of: agreement/disagreement questions on barangay support, parent cooperation, and satisfaction with physical environment, children, job, and life; a modified version of Bandura's (2006) Teacher Self-Efficacy Scale (alpha of .93 in this sample); and Smith, et al.'s (2008) Brief Resiliency Scale (alpha of .84 to .90, in Smith et al., 2008; alpha of .59 in this sample).

Data Gathering and Analysis Procedure

The questionnaires were group administered among the respondents in one of the capacity building sessions they attended. Ethical implementation of the study was ensured by making sure that informed consent was sought and the significance and use of the survey were discussed. Participants were informed about the nature and purpose of the study and their identities were not revealed in any part of this report to ensure anonymity and confidentiality.

After data collection, data were analyzed using descriptive and correlation statistics. Associations between work-related factors and the levels of self-efficacy and resilience were described using cross-tabulations. Relationship among the summative scores on the self-efficacy and resilience scales was on the other hand explored using Spearman rank-order correlation.

Results, Interpretation, and Discussion

Profile of the Study Participants across Work-Related Factors

The first research question inquired about the profile of the study participants in each of the work-related factors explored in this study, especially on areas of support, cooperation and satisfaction. To address this research problem, a set of agreement/disagreement questions were asked so that respondents can express assent or dissent based on their experiences. Table 1 presents the frequency of respondents' distribution according to their agreement/disagreement on the various work-related factors.

Table 1 : Agreement or disagreement on attitude questions on work-related variables

Work-Related Variables	Agree/Yes f (%)	Disagree/No f (%)
Supportive barangay officials	39 (67.2)	19 (32.8)
Cooperative parents	37 (63.8)	21 (36.2)
Satisfying physical working environment	31 (53.4)	27 (46.6)
Satisfying day care pupils	46 (79.3)	12 (20.7)
Satisfying job	55 (94.8)	3 (5.2)
Satisfying life, in general	57 (98.3)	1 (1.7)

As reflected in Table 1, almost all of the respondents perceived themselves as having a satisfying job and a satisfying life. A large number also shared being satisfied with the children they cater to in the day care. These results aligned with the findings of Abulon (2013), which revealed that despite the lack of monetary rewards, Filipino DCWs manifest high satisfaction with their work and life as child development service providers.

Interestingly, while the majority of the respondents were on the affirmative side, they were somewhat divided in terms of perceived support from barangay, of perceived cooperation of day care children's parents, and of their satisfaction with the physical workplace (i.e., physical structure of the DCC). This implies that the CDWs' experiences on the supportiveness and cooperativeness of stakeholders in their community tend to be variable. Although there were more who perceived support and cooperation, a nearly equal number of respondents perceived otherwise. This entails that support and cooperation have to be further explored on a case-to-case basis such that conducting local researches at the barangay-level might provide additional knowledge about the dynamics between and among ECCD stakeholders. It must be noted that Philippine ECCD policy urges parents and local government officials to prioritize the provision of needs among the very young both through home-based and center-based programs (Philippine Congress, 2012). Gaining insights on how stakeholders work towards achieving ECCD goals is favorable.

Another salient point that can be gleaned from the results is the noticeable divide among the respondents regarding their satisfaction about the physical structure of the DCCs. Studies have shown how significant the physical environment is in learning and in the holistic development of the child (World Health Organization, 2004; Higgins, Hall, Wall, Woolner & McCaughey, 2005). Interestingly, improving the built environment also demands communication and collaboration among stakeholders that include parents and community officials (Higgins, et al., 2005; World Health Organization, 2004). Hence, it might be an interesting direction to see in future research how levels of support and cooperation relate to, or even predict, satisfying physical environments in center-based programs such as day care, and, probably, how a satisfying physical environment relates to DCWs' and day care children's educational outcomes. Appropriate attention and planning of the classroom are needed for the learning to meet its goals and needs (Puteh, et.al, 2015).

Perceived Psychosocial Needs and Resources

The second research question explored the perceived needs and resources of day care workers. In general, the study found that needs and resources pertain to any of the following dimensions: financial, material/physical, knowledge, people, and/or personal traits.

Perceived Needs. Respondents were asked to identify needs in order of priority by answering the question: What are your needs as a Day Care Worker? Responses were content analyzed and there were four major categories identified: physical/material, financial, knowledge and people. Strings of statements by the respondents were tallied per category, the frequency distribution of which is presented in Table 2.

Table 2: Frequency distribution of respondents according to perceived topmost needs

Category of Needs	Topmost need	
	f	%
Physical/Material	28	48.28
Financial	16	27.59
Knowledge	9	15.52
People	3	5.17
No response	2	3.45

Physical/Material. Statements pertaining to physical/material needs appeared with the highest frequency in all levels of priority. More than 48% of the respondents indicated physical/material needs as their topmost need. Needs which pertained to physical/material needs that were identified by the respondents were *learning materials, school supplies, toys, books, paintings/murals, DCC classrooms, kitchen, playground, sound system, blackboard, comfort room,* and *renovation of classroom.*

Financial. Some 27.59% of the respondents noted as their first priority statements, which pertain to financial/fiscal needs. Examples of actual statements falling under this category as written by participants are as follows: *money, budget, financial assistance,* and *honorarium.*

Knowledge. Almost 16% of the respondents identified as their first priority needs that fall under the Knowledge category. Examples of actual statements written by participants and which fall under this category are as follows: *seminars, more knowledge, learning, how to do first aid,* and *techniques how to handle children*. The present study did not ask in detail what kind of training the respondents wanted to have although behavior management and first aid administration were specifically identified. Managing children's learning and behavior was among the problems in day care development programs suggested by Elarco (2011). On the other hand, the study of Cadosales (2011), identified content delivery, specifically "teaching the letter sound" (p. 252), as among the activities for enrichment needed by child development workers. Child development workers seem to recognize the need for higher education, training and expertise (Boyd, 2013) to be able to perform their roles better. Early childhood educators are concerned in many different complex skills needed in teaching as well as looking at different issues in their students' speech, language, behavior and others.

People. A category that was least mentioned by respondents as a first priority but which came as a second frequently mentioned need as a second and third priority, was People. Interestingly, while only a little more than 5% of the respondents identified needs related to people as their first priority, approximately 12% of them noted it as a second priority while almost 7% of them noted it as a third priority. People-related needs mentioned by respondents were *cooperation of parents* and *barangay officials.*

Perceived Resources. Likewise, respondents were asked to identify their topmost resources by answering the question: What resources do you have? Content analysis of the responses revealed four major categories: physical/material, people, financial and personal traits, as presented in Table 3.

Table 3: Frequency distribution of respondents according to perceived topmost resources

Category of Resources	Topmost need	
	f	%
Physical/Material	15	25.86
People	13	22.41
Financial	8	13.79
Personal Traits	6	10.34
No response	16	27.59

Physical/Material. Statements pertaining to physical/material resources appeared with the highest frequency as the topmost resource (26% of the respondents). Responses that pertained to physical/material resource as identified by the respondents were *recycled materials, old materials, day care center, surroundings, visual arts, TV* and *comfort room.*

People. Garnering the second highest frequency as a topmost resource identified by 22.41% of respondents, people appeared to be a quintessential resource among CDWs. *Mother, child, parents, barangay officials, barangay captain, CDW,* and *DSWD officials* were among the people-related resources identified by the respondents.

Financial. With the third highest frequency as a topmost resource noted by almost 14% of the respondents, financial resource was also mentioned. Among the responses which fell under this category were *personal income, parents' contribution,* and *registration/entrance fee.*

Personal Traits. While only noted by 10.34% respondents as a topmost resource, personal traits were also among the notable resource worth mentioning. Among the personal traits identified as a resource were *helpful, talent in being a mother, inner strength, political will, willingness to learn, experiences, generosity* and *cooperation*.

Levels of Self-Efficacy, Self-Efficacy Subscales, and Resilience

The third research question in this study focused on the levels of self-efficacy and resilience among the respondents. Table 4 shows respondents' frequency distribution as well as the cross-tabulation between self-efficacy and resilience levels. Low level in a variable was defined as having a score on or below the mean (≤M) while high level was defined as having a score above the mean (>M), as determined throught the samples' distribution. Table 5, on the other hand, presents the mean scores of the study participants in self-efficacy, self-efficacy subscales, and resilience.

Table 4: Cross-tabulating self-efficacy levels with resiliency levels

Resilience Level (R)	Self-Efficacy Level (SE)		
	Low f (%)	High f (%)	TOTAL
Low	14 (24.1)	13 (22.4)	27 (46.6)
High	13 (22.4)	18 (31.0)	31 (53.4)
Total	27 (46.6)	31 (53.4)	58 (100)

Frequency distribution shows that respondents were divided almost equally between the Low and High Scoring groups in both self-efficacy and resilience. Similarly, cross-tabulation shows that categorizing respondents to self-efficacy levels while considering resilience levels, also divided the respondents nearly equally on four groups: High Efficacy-High Resilience (31%), Low Efficacy-Low Resilience (24.1%), High Efficacy-Low Resilience (22.4%) and, Low Efficacy-High Resilience (22.4%).

Table 5: Descriptive statistics on participants' self-efficacy and resilience scores

Study variables	Range of expected scores	M	SD
Self-efficacy (SE)	30-150	121.65	13.30
Efficacy to influence decision-making	2-10	8.45	1.01
Instructional efficacy	9-45	36.66	4.51
Disciplinary self efficacy	3-15	12.79	1.48
Efficacy to enlist parental involvement	3-15	12.33	1.85
Efficacy to enlist community involvement	4-20	13.36	2.96
Efficacy to create a positive school climate	8-40	34.17	4.52
Resilience	6-30	20.88	3.36

Viewing levels of self-efficacy and resilience using measures of central tendency, however, revealed that, at the average, respondents had a mean Self-Efficacy score of 121.65 (SD=13.30) and a mean Resilience score of 20.88 (SD=3.36). These were relatively higher than the expected average score in the scales, which is 90 for self-efficacy and 18 for resilience. The same was true for all the self-efficacy subscales where respondents gained mean scores higher than the expected average scores in the subscales. Perception of high resilience among child care providers has already been mentioned by Bouillet, Ivanec and Miljević-Riđički (2014).

What the current finding offers as a novel insight is how the CDWs perceived their self-efficacy. Apparently, the respondents believed that they are highly self-efficacious, in general, and even in aspects of decision-making, instruction, discipline, encouraging community and parental support, and creating a positive climate in the day care. These results may gain light when viewed against earlier findings associating self-efficacy and life and job satisfaction (Chen & Scannapieco, 2010). Although there was no attempt in the present study to sophisticatedly associate satisfaction and efficacy, it must be noted that the respondents reported high satisfaction about their job and life, and this might just link with their high level of self-efficacy and vice versa. Henceforth, an interesting direction to pursue is to further establish the interaction between work-life satisfaction and efficacy among Filipino DCWs using elaborate psychometric measures to establish how strong and generalizable this association is.

Work-Related Factors, Self-Efficacy, and Resilience

The fourth research question problematized how the various work-related variables explored in this study relate with self-efficacy and resilience. Since the respondents were purposively selected, more sophisticated statistical measures of association could not be employed. Hence, descriptive cross-tabulation was used to glean interactions that may reveal points of interest in future studies. Emphasis in the discussion was given on respondents who fell under high efficacy (31 of 58) and high resilience (31 of 58) groups.

Table 6: Cross-tabulating self-efficacy and resiliency levels with perceived support from barangay

Perceived Support from Barangay	Self-Efficacy Level (SE)			Resilience Level (R)		
	Low f (%)	High f (%)	Total	Low f (%)	High f (%)	Total
Unsupportive	9 (15.5)	10 (17.2)	19 (32.8)	9 (15.5)	10 (17.2)	19 (32.8)
Supportive	18 (31.0)	21 (36.2)	39 (67.2)	18 (31.0)	21 (36.2)	39 (67.2)
Total	27 (46.6)	31 (53.4)	58 (100)	27 (46.6)	31 (53.4)	58 (100)

Notably, 21 of 31 or some 68% of those with high level of self-efficacy, and 21 of 31 or some 68% of those with high level of resilience perceived officials in their barangay as supportive. Policy-wise, the Philippine government, through the Republic Act No. 6972, otherwise known as Barangay-Level Total Development and Protection of Children Act, (Philippine Congress, 1990), stresses the involvement of the barangay, in the promotion of child care and development goals, through the establishment of the DCCs, now referred to as the child development centers. The immediate community is a source of support to the caregivers in community-based childcare center, which, in turn, serves as a doorway for the provision of other social services that relate to health, nutrition, water and sanitation and the like (Munthali, Mvula, & Silo, 2014). Hence, when the child development worker deems barangay officials as supportive to the projects and activities of the DCC, the former becomes more confident that s/he will be able to achieve the desired outcomes for the day care, and will also be spirited enough even when faced with challenges.

Notwithstanding the role the barangay plays in teacher self-efficacy and resilience, Reyes (1996), in an evaluation of the implementation of day care policy in the Philippines, however, suggested that looking at smaller units such as “purok” or zones, rather than the barangay, as target areas for the creation of DCCs might make the day care program more manageable. From this, it can be speculated that, perhaps, barangay governments’ cooperation with the day care worker might also be challenged by confounding priorities, which can possibly be addressed by engaging a smaller group of families to own the day care program and be deeply involved in it. This leads to the issue of parental cooperation.

Table 7 : Cross-tabulating self-Efficacy and resiliency levels with perceived parental cooperation

Perceived Parental Cooperation	Self-Efficacy Level (SE)			Resilience Level (R)		
	Low f (%)	High f (%)	Total	Low f (%)	High f (%)	Total
Uncooperative	11 (19.0)	10 (17.2)	21 (36.2)	10 (17.2)	11 (19.0)	21 (36.2)
Cooperative	16 (27.6)	21 (36.2)	37 (63.8)	17 (29.3)	20 (34.5)	37 (63.8)
Total	27 (46.6)	31 (53.4)	58 (100)	27 (46.6)	31 (53.4)	58 (100)

In this study, the majority of the respondents with high efficacy and with high resilience also perceived that parents in the day care were cooperative (21 of 31 or appx. 67%, and 20 of 31 or appx. 65%, respectively). There was no available literature explaining this result in the context of CDWs' work. However, studies on elementary school teachers noted that there is positive relationship between teacher self-efficacy and parent support (Stipek, 2012). On the other way around, a study among preschool teachers noted that the teacher also has to strategize to enhance parental involvement, thereby also making parents more self-efficacious (Pelletier & Brent, 2002). Most importantly, the day care worker and the day care parents have to dialogue and level off in terms of what parental involvement means, as a study also showed that parental involvement is perceived differently by various stakeholders (Herrell, 2011).

Table 8. Cross-tabulating self-efficacy and resiliency levels with perceived satisfaction

Satisfaction	Perceived Satisfaction	Self-Efficacy Level (SE)		Resilience Level (R)	
		Low f (%)	High f (%)	Low f (%)	High f (%)
Physical structure of the DCCs	Unsatisfied	12 (20.7)	15 (25.5)	12 (20.7)	15 (25.5)
	Satisfied	15 (25.9)	16 (27.6)	15 (25.9)	16 (27.6)
Children being catered to	Unsatisfied	7 (12.1)	5 (8.6)	4(6.9)	8(13.8)
	Satisfied	20 (34.5)	26 (44.8)	23 (39.7)	23 (39.7)
Job as a day care worker	Unsatisfied	0 (0)	3 (5.2)	1(1.7)	2 (3.4)
	Satisfied	27 (46.6)	28 (48.3)	26(44.8)	29(50.0)
Life, in general	Unsatisfied	0 (0)	1(1.7)	0 (0)	1(1.7)
	Satisfied	27 (46.6)	30(51.7)	27 (46.6)	30(51.7)

Most importantly, many of those who fell into the group with high efficacy and high resilience also perceived being satisfied in various aspects of their work life such as with the pupils they cater to (26 of 31, and 23 of 31, respectively), with their job (28 of 31, and 26 of 31, respectively), and with their life in general (30 of 31, and 30 of 31, respectively). Skaalvik, E.M. and Skaalvik, S. (2010) gleaned that job satisfaction links well with self-efficacy, especially among teachers. Resilience has also been deemed as associated with job satisfaction among nurses (Matos, Neushotz, Griffin, & Fitzpatrick, 2010), and happiness among preschool teachers (Mojdegan, Moghidi, & Ahghar, 2013). In the study among preschool teachers, Yousofi, Rezaei, and Yonesi (2014) found that self-efficacy is a correlate and predictor of job satisfaction. Remarkably, they also found job motivation as related to efficacy. In the case of the CDW, it may be interesting to further explore what are their motivations at work, which make them highly satisfied. In the present study, being with children was gleaned as satisfying.

It might be explored more comprehensively in succeeding research as a potential job motivator associated with efficacy and resilience, especially that caring for others, i.e., the children one caters to, is deemed as a source of well-being for teachers (Nilsson, Ejlertsson, Andersson, & Blomqvist, 2015).

Having gleaned the profile of work-related factors vis-à-vis levels of self-efficacy and resilience, it can be said that, in this particular study, highly efficacious and resilient CDWs are characterized as having: supportive barangay officials; cooperative day care children's parents; satisfaction with pupils; job satisfaction; and life satisfaction in general.

Intercorrelations among Self-Efficacy, Self-Efficacy Subscales, and Resilience

The fifth and last research question in this study desired to describe the nature and magnitude of association between and among self-efficacy, its subscales, and resilience. After testing for assumptions, correlation was calculated using the Spearman rank-order technique. Table 9 presents the correlation coeffecients derived from this analysis.

Table 9: Correlations among self-efficacy, self-efficacy subscales, and resilience

Study Variables	DM	IE	DE	PI	CI	SC	Resilience
Self-efficacy (SE)	.592	.896	.660	.729	.678	.902	.333
Efficacy to influence decision-making (DM)		.496	.219	.318	.383	.545	.119
Instructional efficacy (IE)			.579	.624	.425	.789	.274
Disciplinary self-efficacy (DE)				.547	.399	.544	.201
Efficacy to enlist parental involvement (PI)					.441	.580	.308
Efficacy to enlist community involvement (CI)						.474	.252
Efficacy to create a positive school climate (SC)							.358

Correlation analysis revealed that self-efficacy has a positive moderate correlation with resilience ($r = 0.333$), such that along with the increase in the respondents' belief that s/he is able to perform tasks as a child development worker was also an observable increase in her/his perceived ability to bounce back from adversities, vice versa. This result supports the earlier findings of Mojdegan, Moghidi, and Ahghar (2013), which established significant relationship between self-efficacy and resilience among preschool teachers in Iran, and the results of the study of Kusma, Groneberg, Nienhaus, and Mache (2012), which revealed positive correlation between self-efficacy and resilience among early childhood educators.

According to Bandura (1997, 1977), self-efficacy predicts behaviors. When understood from the context of CDWs who are faced with various responsibilities, having a belief that one is capable of influencing various dimensions of work and profession (self-efficacy) may be necessary in reassuring oneself that one is capable of thinking, planning and executing activities that would unlock difficulties and challenges (resilience). Similarly, a child development worker who perceives oneself as capable of transcending adversities (resilience) may tend to feel more abled in influencing one's working environment (self-efficacy).

Exploring specifically on the self-efficacy subscales provides additional information as to how this link between resilience and self-efficacy might ensue. Among the subscales, efficacy to involve parents (r = 0.308) and efficacy to foster a positive learning climate (r = 0.358) were the ones which resilience had positive moderate correlation with. This is consistent with the earlier result of the cross-tabulations on self-efficacy and parental involvement. As parents are perceived as more cooperative, the DCW might feel more adequate in influencing parental involvement, hence, gain confidence in one's ability to face adversities side by side with the day care children's parents. The day care children's parents might act as social support upon which the day care worker can rely in challenging times, especially in concerns related to child care and development. In conjunction with this parent-CDW relationship is also the ability of the DCW to establish an environment nurturing enough for collaboration to take place, as well as, conducive enough for the delivery of effective services for the day care children.

Furthermore, looking at the inter-correlations among the self-efficacy subscales, it could be gleaned that efficacy to influence decision making had a high positive relationship with fostering positive school climate (r = 0.545), while low to moderate positive relationship with the rest. Hughes and Pickeral (2013) noted that positive school climate is a shared responsibility among the different stakeholders. Hence, a DCW who finds oneself efficacious in making decisions,that is, having sufficient share of power and responsibility within the working environment,may also tend to feel efficacious in promoting a positive and conducive climate in the day care environment.

Instructional self-efficacy, on the other hand, had *high* positive relationship with most of the subscales, with correlation coefficients ranging from 0.579 to 0.789, except with community involvement with which the relationship was moderate positive. Disciplinary self-efficacy also had moderate to high positive relationship with several subscales, except with influencing decision-making (r = 0.219) and encouraging community involvement (r = 0.399), with which it had low to moderate correlation.

In the Philippines, the day care does not only act as platform for health and psychosocial services but also serve as a learning platform (UNESCO, 2007). This reality, perhaps, makes instructional and disciplinary efficacy a quintessential dimension of DCWs' general self-efficacy. The DCCs mends the gap that families' inability to afford pre-school education creates, which motivates the CDW to focus on teaching, among other tasks. The high degree of association between instructional and disciplinary efficacy with the rest of self-efficacy subscales might insinuate that CDWs' efficacy in other dimensions strongly goes along with their efficacy in facilitating learning and managing children's behaviors. This insight fits well with the findings of Cadosales (2011), which underscores CDW's expressed need for activities that will train them become better in teaching, specifically in "teaching strategies, production of instructional materials, and pedagogy" (p.247).

Finally, efficacy in encouraging parental involvement, encouraging community involvement, and fostering positive climate all had moderate to high positive relationship with other subscales, with coefficients ranging from 0.318 to 0.789. As constantly manifested in aforementioned discussions, the DCWs self-efficacy links with their ability to mobilize parents, families, and the community to take part in promoting care and development of the very young.

Summary, Conclusion, and Recommendations

In conclusion, this descriptive study established that, in this particular group of selected CDWs:

1. The majority reported satisfaction with the children they cater to, their work, and their life in general.
2. There was no distinct consensus regarding their perceptions on barangay support, parental involvement, and satisfaction with the physical structure of the day care.
3. The majority of highly efficacious and highly resilient CDWs also perceived having support, cooperation, and satisfaction.
4. Self-efficacy and resilience are moderately and positively correlated.

The sparse literature about CDWs in the Philippines made it challenging for this study to situate the analysis of its findings against the backdrop of real experiences from Filipino DCWs. Insights from allied areas such as early childhood education, taking heed from what is known regarding self-efficacy and resilience of preschool teachers and other childcare providers (e.g., nurses), however, made it somewhat possible to clarify the nature of association among the study variables and its implication on the circumstances of CDWs. Insights from the limited local literature on day care programs were also deemed meaningful. Hence, this study highly recommends that considerable research attention be given to child development programs and its stakeholders in the Philippine setting. Both qualitative and quantitative empirical explorations would be meaningful in bridging the knowledge gap. Validating the outcomes of this study by having a larger and randomly selected sample, alongside conducting in-depth qualitative investigations, might also provide a more comprehensive and holistic overview on CDWs' efficacy and resilience and on CDWs' lived experiences, in general.

Taking into consideration the outcomes of this study, several opportunities emerge in both research and extension activities with and for CDWs. Exploring signature strengths of CDWs might be meaningful. While there was a mention of a few personal traits as resource, there remains to be more focus on external resources, i.e., physical/material, financial, people, which, although are equally important, might come in arbitrary forms and amount. There is a need to solidify internal resource capabilities such as values, character and ego strength so as to dispose the CDWs for the grueling duties demanded from them.

Capacity building, particularly in resource generation and inter-agency collaboration, may help CDWs exhaust all potential fiscal support within the community. Integrating exercises to explore inner strengths might also be a direction in extending support among CDWs. At the forefront of the government's thrust to strengthen ECCD at the local level is the CDW patiently steering the program's rudders on a daily basis. Providing the CDWs with opportunities to enhance their efficacy and resilience by providing them with more opportunity to take part in decision making in the day care, encouraging active parental and community involvement and designing and implementing capacity building programs that would enhance their skills in pedagogy and child care, might just promote their confidence in their field as professionals, and might just inspire them to continuously become better as caregivers to the Filipino child.

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Corresponding author: Katherine Del Rosario
Contact email: kedelrosario@up.edu.ph

Role of Educational Technologies Utilizing the TPACK Framework and 21st Century Pedagogies: Academics' Perspectives

Tirtha Goradia
Endeavour College of Natural Health, Australia

Abstract

With the rapid development in information technology and the need to acquire 21st century skills, global trends in higher education are shifting towards using digital pedagogies. In light of this, Koehler and Mishra (2009) developed the Technological Pedagogical Content Knowledge (TPACK) framework to integrate technology with teaching. The framework has now been explored and implemented in various educational institutions. This study aims to collect academics' perspectives on various technologies and pedagogies used at the institute through the lens of the TPACK framework. A mixed-methods study, using a survey-based questionnaire, was undertaken to collect academics' perspectives. The study revealed a wide range of technologies and pedagogies being used to enhance 21st century competencies and skills. The TPACK framework provides a useful tool to gauge the learning environment and displays a complex interaction between technology, pedagogy and content knowledge specific to the learning environment. The results highlight the need to use technology for innovation and to renovate contemporary teaching practices for 21st century learning.

Keywords: TPACK, pedagogies, technologies, higher education, 21st century

Introduction

The last decade has seen an exponential increase in the use of information technology within the Higher Education (HE) sector. Most higher education institutions have incorporated teaching with technology to enhance the learning experience for students. New learning technologies are being implemented with the aim of enhancing student engagement and academic outcomes. With the development in information technology, current trends in HE are now embracing a wide range of technologies which include, but are not limited to, discussion forums, simulation, virtual reality, webinars, wiki space, Kahoot, as well as social media technologies.

Further, as a result of globalization in HE and the demands of current knowledge age, the needs of the 21st century learners have been changing. 21st century pedagogies have therefore stemmed from this need to provide learners with the opportunity to develop necessary competencies and skills to meet the current demands. Global trends in HE are therefore shifting towards digital pedagogies. According to Lai (2011) digital technologies can enhance learning experiences when used as a medium to support collaboration and construction of knowledge.

This paper reviews the TPACK framework as developed by Koehler and Mishra (2009). The TPACK framework was introduced with the aim of integrating technology into teaching. The framework involves a complex interaction among three major components: content, pedagogy, and technology. TPACK studies have been explored in various educational institutions to study the relationship between technology and pedagogy with opportunities, as well as challenges, having been identified in the process. The TPACK model has allowed for increase in both student engagement and collaboration, as well as flexibility in learning (Lye, 2013). Academics considered the TPACK framework as a heuristic for exploring the dynamic elements for effective teaching with technology (Glowatz & O'Brien, 2017). On the other hand, academics perceive limitations with specific tools in terms of design and usage and have raised concerns with use of TPACK framework in the context of specific tools such as social networking sites (Glowatz & O'Brien, 2015, 2017; Lye, 2013).

This study evaluates academics' perspectives on various technologies and pedagogies that are being used at the institute to determine whether they contribute to 21st century learning. The data would allow academics to rethink about digital technologies and how this can improve learning experiences.

Literature Review

Shulman (1986, 1987) described the categories of knowledge that a teacher requires to promote comprehension among students. In particular was the knowledge of content and pedagogy that blended together to create a flexible learning environment for diverse groups of students. The TPACK framework builds on Shulman's work to include technology for effective teaching and emerges from interactions among content, pedagogy, and technology Koehler and Mishra (2009).

Components of TPACK framework

The three main components of the framework are: Content knowledge, Pedagogical knowledge and Technological knowledge. See Figure 1.

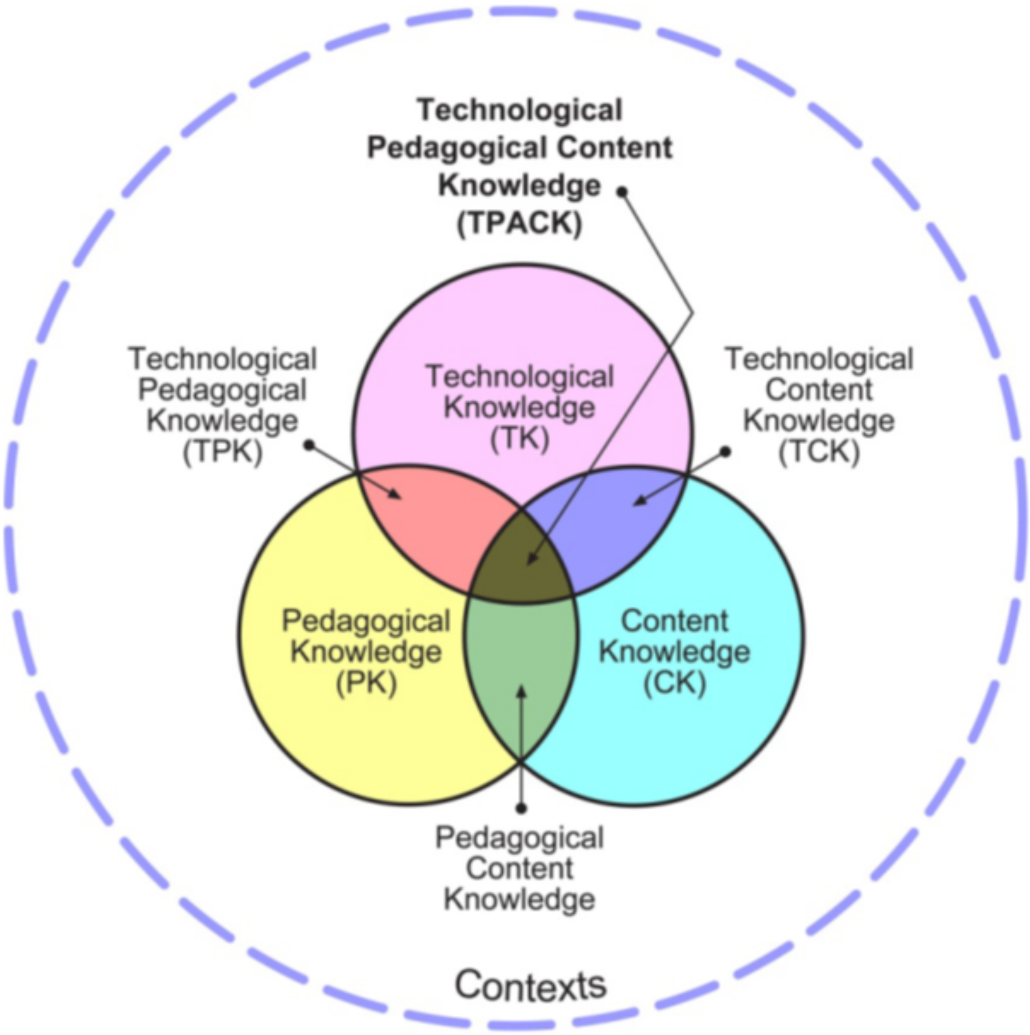

Figure 1. The TPACK framework and its knowledge components (Koehler & Mishra, 2009)

Content knowledge involves the lecturers' grasp on the subject content. This would include scientific facts, theories, evidence-based reasoning as well as discipline specific practices. Pedagogical knowledge involves lecturers' knowledge about teaching and learning. This includes ways of representing and formulating the subject content that make it comprehensible to others (Shulman, 1986). Technology knowledge involves understanding technology for information processing, communication, and problem solving (Koehler, Mishra, & Cain, 2013).

A complex interaction between the three domains gives rise to an additional three components: pedagogical content knowledge, technological content knowledge and technological pedagogical knowledge (see figure 1.) Technological cntent knowledge refers to lecturer's knowledge on use of appropriate technology in order to communicate the content material within specific discipline. Pedagogical content knowledge includes appropriate methods of teaching to convey a specific content. Here the teacher knows the subject matter and uses different ways of representing it. Technological pedagogical knowledge demonstrates how a particular technology enhances teaching and learning. Technology can be used differently to suit the context and purpose.

The framework has been implemented in various educational institutions with most of them reporting average levels of technology integration in their teaching and learning process. The studies have identified further need for improvement in technological, pedagogical and content aspects of teaching and learning skills (Benson & Ward, 2013; Lye, 2013). While some educators emphasize technology over pedagogy, others prefer pedagogical knowledge over technology for an effective TPACK implementation. In contrast, other studies have found improvement in students' knowledge and skills especially within the science domain (Sheffield, Eva, Gibson, Mullaney, & Campbell, 2015). In general most educators believe competency with TPACK as a core attribute essential for professional development in the teaching and learning environment.

21st Century

The need for 21st century learning and skills. Today's world faces challenges such as climate change, socio-economic inequality, unemployment, globalization, and cultural diversity. "The 21st century is volatile, uncertain, complex and ambiguous" (Acedo & Hughes, 2014, p. 504). Additionally, with the development in information technology there is a growing need to keep abreast with technology. Educators, therefore, highlight the importance of restructuring education system such as to prepare 21st century learners to face these complex challenges. Educators as well as the public support the notion that higher-order thinking skills are essential to face these complex issues and involve creativity, critical thinking, collaboration and lifelong learning (Acedo & Hughes, 2014; Sacconaghi, 2006; Scott, 2015)

21st century skills. The Framework for 21st Century Learning (Partnership for 21st Century Learning, 2007) identifies the skills, knowledge and expertise required by students in order to be successful in the current digital economy. The 21st century skills are categorized as: learning and innovation skills (creativity, critical thinking, problem solving, communication and collaboration); information, media and technology skills; and life and career skills. These are briefly described below (Applied Educational Systems, 2018):

> Creativity: Allows students to review concepts from a different perspective which ultimately leads to innovation.
> Critical thinking: A skill that allows students to analyze evidence and form judgement to solve problems.
> Problem-solving: Refers to the ability to solve problems in an effective and timely manner.
> Communication: A skill that allows students to effectively convey ideas amongst peers.
> Collaboration: Collaboration means getting students to work together in order to find solution to a problem.
> Information literacy: Understanding facts, figures, statistics, and data.
> Media literacy: Understanding the methods in which information is disseminated.
> Technology literacy: Understanding of the tools used to disperse the information.
> Life and Career skills: Allows for personal and professional growth thereby leading to lifelong learning.

21st century pedagogies. Several educators have highlighted the significance of 21st century pedagogies (Acedo & Hughes, 2014; Breslow, 2015; Kivunja, 2014, 2015; Scott, 2015). These are the pedagogies that develop higher-order thinking skills, metacognitive skills, and support deeper learning through collaboration.

Unver and Arabacioglu (2014) have reflected on inquiry-based learning (IBL) and problem-based learning (PBL) as pedagogies that can solve current age challenges through the acquisition of problem solving skills. The authors identify IBL as a learning activity whereby learners acquire knowledge from direct observations by using deductive questions. They further differentiate it from PBL as a learning activity whereby learners learn through investigation, explanation and resolution of meaningful problems. Similarly, Snow and Torney (2015) through their mixed-methods study suggest that inquiry-based learning has the potential to develop students' cognitive skills at a higher level thereby promoting problem-solving, critical thinking and leadership skills. Furthermore, empirical research on inquiry-based learning reveals enhanced academic performance and student engagement in students using this pedagogy (Summerlee & Murray, 2010).

Several researchers have reviewed collaborative learning as a pedagogy to facilitate learning (Beccaria, Kek, Huijser, Rose, & Kimmins, 2014; Fakomogbon & Bolaji, 2017; Scott, 2015). In particular, the study by Fakomogbon and Bolaji (2017) revealed that collaborative mobile learning through portable devices or smartphone could enhance motivation, academic outcomes, and engagement through sharing knowledge, group discussions, and group assessments with group members. According to Scott (2015), learners through collaborative learning participate in higher-order thinking such as managing, organizing, critical analysis, problem resolution, and creating new knowledge.

The availability of digital technologies has also generated informal ways of learning to support formal studies (Kwok-Wing & Smith, 2017). Digital technologies such as laptops, mobile phones, Google, iPads, tablets, as well as social networking sites such as Facebook and Twitter are quite popular among students and are being used to complement formal learning methods. Several researchers, therefore, are now investigating the role of informal methods within the learning space. Kwok-Wing and Smith (2017) suggest incorporating mobile and digital technologies in the formal courses in conjunction with more traditional methods of learning in order to cater for the diverse learning style of students. Kivunja (2015) recommends higher education institutions to utilize social media technologies as effective pedagogies to support effective learning, teaching and assessment in the 21st century. These technologies create opportunities for experiential learning. The author believes that experiential learning can be a very effective way for cognitive processing as it involves the reciprocal exchange of discourse amongst students so as to develop a deeper understanding of pedagogical content knowledge.

Yet another pedagogy that has been explored in higher education is constructivist learning which emerges from the concepts developed by pioneers, Piaget and Vygotsky. Constructivist learning allows for students to actively construct their own knowledge in order for learning to be meaningful and effective (Afify, 2018; Alt, 2017; Asiksoy & Ozdamli, 2017; Noel, 2015; Scott, 2015). Noel (2015) suggested use of blogs in education to create a constructivist learning environment that supports knowledge development through student engagement, reflection and collaboration. Asiksoy and Ozdamli (2017) in their study on education technologies for constructivist learning found that the most frequently used tool was the computer and the most common platform was learning management system. Additionally, Afify (2018) found digital concept mapping an effective tool in support of constructivist learning theory.

Scott (2015) believes the current educational system with fixed curriculum and delivery method obscures personalised learning and suggests the need to adopt personalised learning for 21st century education. This form of learning caters to individual needs of students and can be achieved by using flexible curricula and learning opportunities (Deed et al., 2014; Scott, 2015; Waldrip, Yu, & Prain, 2016). For students, this allows development of autonomy, motivation, and self-regulation (Deed et al., 2014; Scott, 2015). Emerging technologies such as mobile applications, e-portfolios, blogs, audios, videos allow implementation of personalized learning. The shift from traditional educational system to adopting more personalized learning would require a major cultural change in higher education institutions and involvement of various stakeholders.

Among recent trends in higher education, flipped learning is gaining much attention as a new pedagogy. In a flipped classroom, lectures are viewed beforehand whilst in the class students are engaged in more student-centered activities in collaboration with other students, and applying knowledge (Kyung Hye, Kwi Hwa, & Su Jin, 2018; Sletten, 2017; Zipp, Maher, & Olson, 2017). A flipped environment has the potential to improve student' motivation to learn, enhance self-directed learning skills, and promote reflection and critical thinking, thereby enhancing learning (Zipp et al., 2017). However, the flipped learning method has gained mixed review with some academics reporting success while others facing challenges. Further research in this area is being conducted to understand the applicability of flipped learning within higher education institutions.

Rationale

21st century pedagogies should rely on research based pedagogies and learning technologies through real world contexts. The rationale for this research was therefore to collect academics' perspectives on various technologies and pedagogies being used at our institute through the lens of the TPACK framework. The data collected through this study will provide a detailed snapshot of whether the technologies and pedagogies contribute to 21st century competencies and skills. As graduates from Endeavour College of Natural Health are natural health practitioners who would have to engage with the demands of the current knowledge age, they would need the competencies and skills to face such demands. Therefore this study will also help in providing data to the college for the development of appropriate skills.

Methodology

The study was conducted at Endeavour College of Natural Health which is a national provider of complementary medicine in Australia and the departments include Biosciences, Naturopathy, Nutrition, Acupuncture, and Myotherapy. This involved a mixed methods study using a survey based questionnaire. The mixed methods research design was considered for this study as the objective of the study was to gather qualitative and quantitative responses. The quantitative responses would gather information on the use of technologies and pedagogies with respect to frequency while the qualitative responses would gather information on academics' perspectives. The survey instrument covered technologies that were being used at the college and covered pedagogies that were discussed in the literature review. As the study aimed to gather academics' perspectives, all teaching staff were approached for this research. Participants involved permanent staff and casual academics across all departments as in figures 2 and 3. An estimate of 100 participants was made based on the current teaching capacity at the college. Ethics approval was gained from the Human Research Ethics Committee and Endeavour Research Committee. Once ethical approval was obtained, academics were approached and provided with the link to the survey. An information sheet and consent form was included on the front page of the survey instrument. The survey outlined the aims and purpose of the study, including a description of what is required of the participant once e-consent is obtained. The information sheet also explained that the participation in the survey is voluntary and if they do not agree to participate they would remain anonymous. Those agreeing to participate would also remain anonymous. The survey comprised of five sections. Section A gathered information on participants' profiles. Section B gathered information on reasons for using technology, content taught using this technology as well as any perceived constraints. Section C explored the Pedagogical Content Knowledge component by framing the research question: How did this pedagogy help in teaching specific content? Section D explored Technological Content Knowledge by framing the research question: How did this educational technology/tool best suit to address subject specific content? Lastly section E explored Technological Pedagogical Knowledge by framing the research question: How did this technology enhance student learning?

Participants were provided with a list of pedagogies with a brief description for each. Following are the 21st century pedagogies identified based on the literature review:

> Problem-Based learning - An approach where students acquire the knowledge through solving the problem. The aim here is to solve the problem. For example: Case studies.
> Inquiry-Based learning - An approach where a problem/scenario is used to incite students to question context, to find information that supports underlying principles and to reflect upon the wider implications. The aim here is to raise questions.
> Constructivist learning - An approach where students actively construct their own understanding/knowledge through student-student and teacher-student collaboration in order for learning to be meaningful and effective.
> Personalized learning - Learning is personalized when learners are motivated to learn as they view the learning task as being engaging and meaningful. Pedagogies that cater for individuals.
> Collaborative learning - A form of social interaction that allows students to share their ideas and learning experiences, thereby promoting learning performance of the group as well as of individuals. For example: group assessment.
> Informal learning - As opposed to formal learning, informal learning is interest driven and occurring incidentally, done in one's own time or through participation in various social groups using digital and mobile technologies.
> Flipped learning - As opposed to a conventional class, flipped learning is an approach where information is introduced to students before class using technology (such as mobile devices) thereby allowing more engaging learning activities during in-class time.

Data Analysis

Pedagogies and technologies were analysed with respect to frequency and qualitative responses. The data gathered by both research methods was brought together to reveal a complete picture. The integration occurred during the interpretation of qualitative and quantitative results. Subgroup analysis of qualitative responses was done. The responses to reasons provided for using particular technologies were grouped into following categories:

student engagement, improving retention, collaborative work, notification, flexibility, user friendly, assessment purposes, learning purposes, national consistency, and teaching purposes.

Results and Discussion

The findings from the survey analysis are presented in this section. The profile of the participants in the survey captures representation across both casual and permanent staff and the time period they have been teaching at the institute. 20 participants responded to the survey.

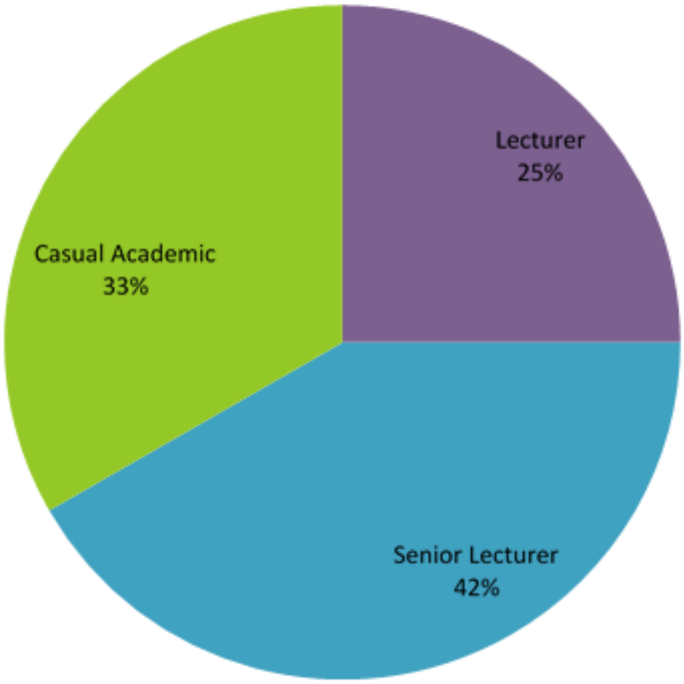

Figure 2. Position in college

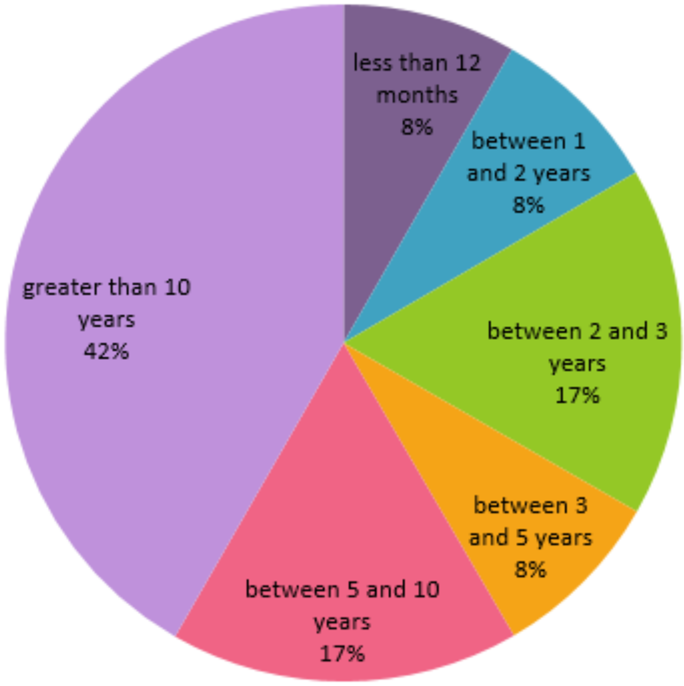

Figure 3. Duration of time teaching at college

Reasons for using particular technologies

Figures 4 and 5 review reasons for using particular technologies. The qualitative responses on reasons for using various technologies received from the participants were grouped into categories such as: student engagement; improving retention; collaborative work; notification; flexibility to students; user friendly; assessment purposes; learning purposes; national consistency; and teaching purposes. The results show that a discussion forum was highly rated by our participants and student engagement was a common reason for using various technologies. This finding is similar to that found in a research conducted by Glowatz and O'Brien (2017) where discussion forums in the form of the learning management system was widely used and student engagement appeared as the driving influence for using various technologies. Online quizzes were considered user friendly as they allowed for automatic grading thereby saving marking time. An online quiz, discussion forum and wiki forum were tools rated for assessment purposes. Additionally, YouTube, concept maps, virtual patient, screencast recordings, webinar, e Portfolio and Kahoot were the tools considered for teaching and learning purposes. These are the tools that allow for visual, kinesthetic, and auditory activities and therefore are important technologies to cater to different types of learners. Participants were also asked to identify any constraints in using technologies. The reasons were categorized as tools not being applicable to the discipline, logistic issues, and tools not suitable to the context. Participants also reported that students often preferred to contact the lecturer through email as opposed to making any posts on the discussion forum.

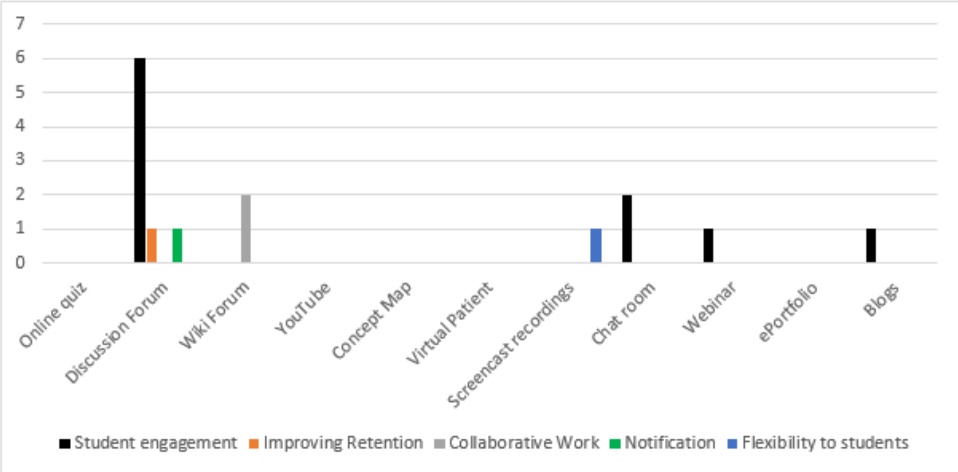

Figure 4. Reasons for using particular technologies

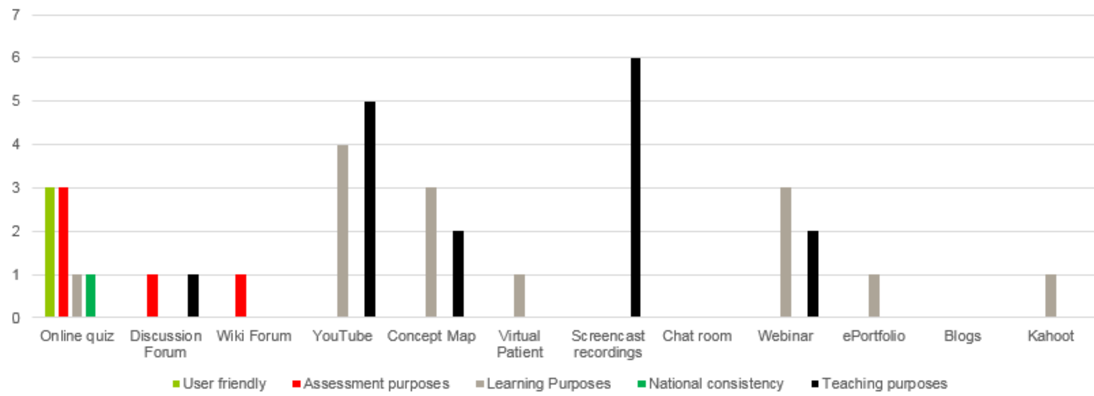

Figure 5. Reasons for using particular technologies

Pedagogical Content Knowledge

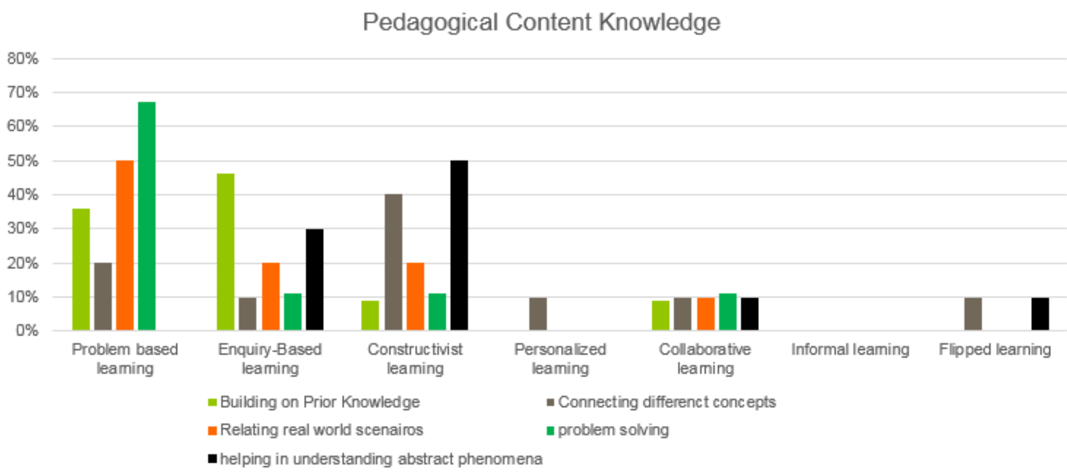

Figure 6. Pedagogical Content Knowledge

Figure 6 represents information on how the pedagogy helped in teaching specific content including whether it built on prior knowledge; related to real world scenarios; helped in understanding abstract phenomena; connect different concepts; and/or allowed problem solving. Participants were asked to rate the 21st century pedagogies to show how they helped in teaching specific content.

Our findings reveal that problem based learning, enquiry-based learning and constructivist learning were highly rated. These are the pedagogies that enhance deeper learning as opposed to superficial learning and promote higher order thinking skills. In contrast, collaborative learning had minimal rating. Other research (Dureta, Christley, Denny, & Senior, 2018; Fakomogbon & Bolaji, 2017; Kivunja, 2015) has shown positive correlation between collaborative learning and academic outcomes and also emphasized use of collaborative assessments. Scott (2015) believes that unless knowledge is created, communicated and shared through collaboration, this can stifle creativity and creativity is an important element of 21st century competencies. Our finding on collaborative learning therefore seems a concern. Our findings also show minimal rating for personalized learning and flipped learning. Besides, there has been significant research on use of social media platforms such as Facebook and mobile technologies as educational tools. These tools are also popular with students. However, our research has shown contradictory results with no rating for informal learning.

Technological Content Knowledge

The research question framed to address this component of the TPACK framework was: How did this technology/tool best suit to address subject specific content? Participants were asked to indicate how technology helped in understanding the content. Figures 7, 8, and 9 revealed tools used for understanding abstract phenomena, 3D concepts and accessing additional resources respectively.

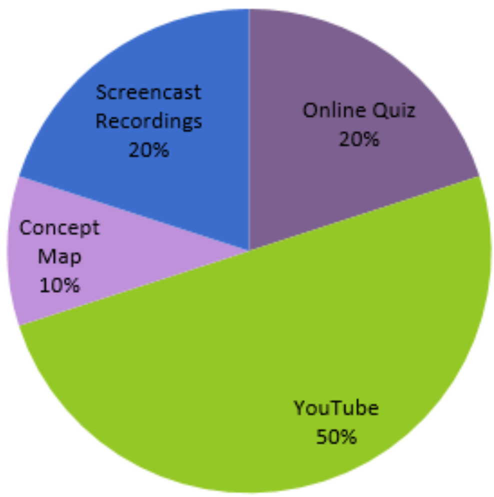

Figure 7. Helped in understanding abstract phenomena

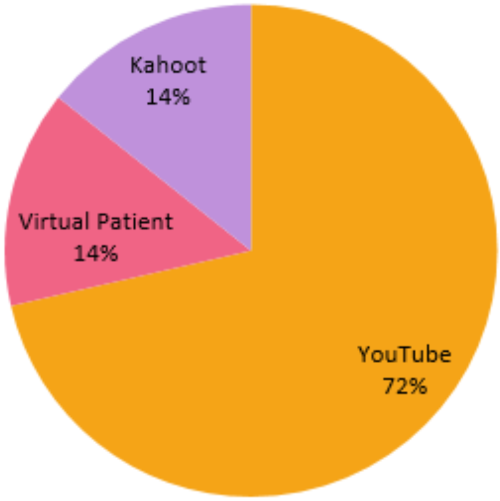

Figure 8. Helped in understanding 3D concepts

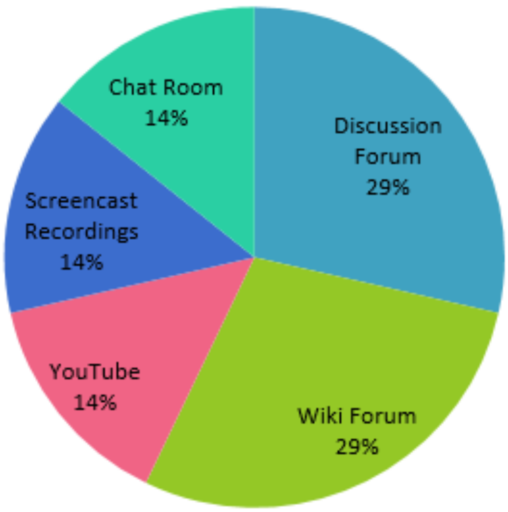

Figure 9. Accessing additional resources

Technological Pedagogical Knowledge
Figures 10 and 11 show responses to how the technology enhanced student learning.

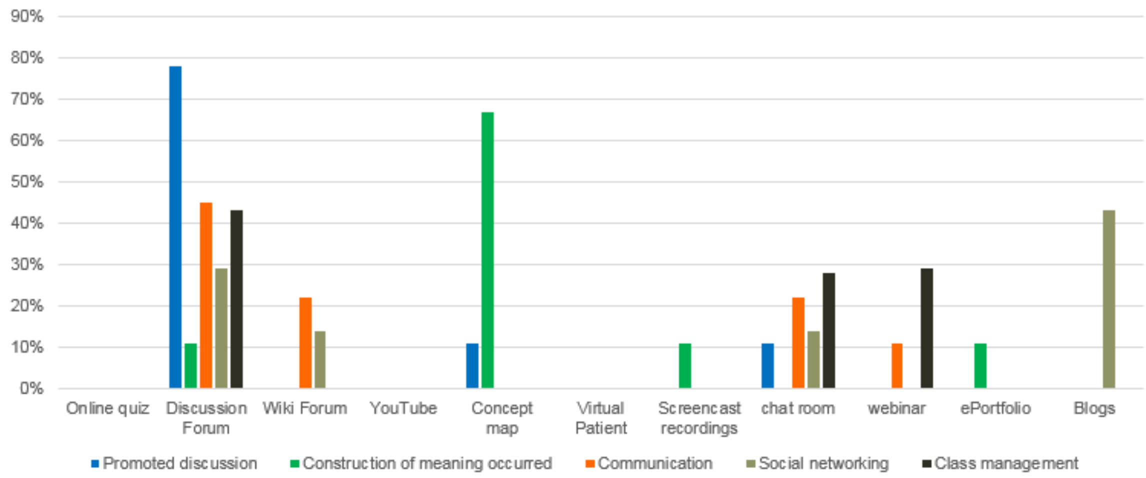

Figure 10. Technological Pedagogical Knowledge

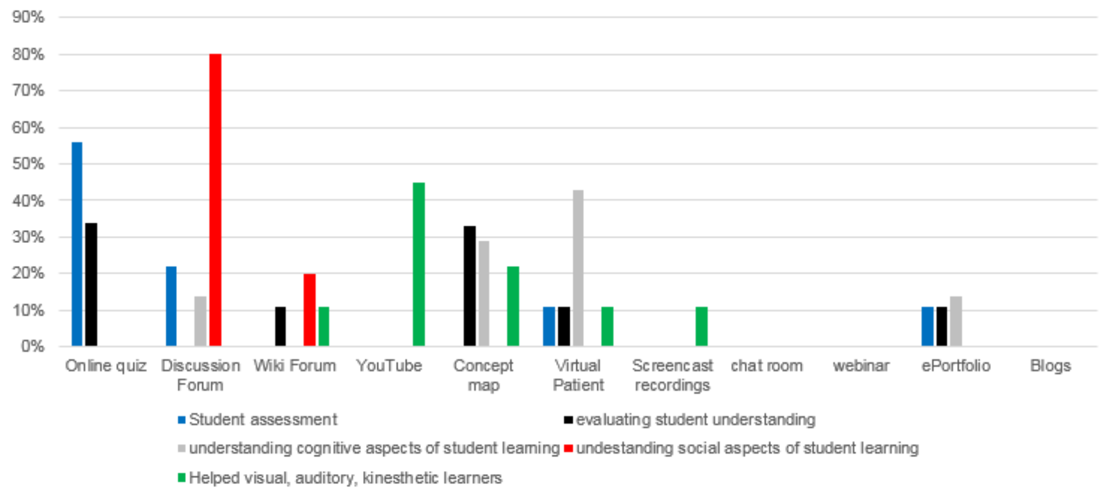

Figure 11. Technological Pedagogical Knowledge

Pedagogical knowledge encompasses knowledge of various teaching strategies; student learning processes, class management; evaluating student outcomes; and above all understanding cognitive, social, and behavioral aspects of student learning. Therefore, our participants were asked to rate various technologies against wide range of pedagogical criteria. While every technology had a specific role in enhancing learning environment, discussion forum was the highly rated tool and fulfilled a wide range of pedagogical criteria. This information could also be discipline specific as the technology tools are related to discipline specific pedagogies. As the majority of our participants belonged to the Biosciences department, there could have been an element of bias although similar findings are found in other TPACK related research. TPACK studies conducted over the period from 2002-2011 had science and mathematics as major subject domains where TPACK studies were explored (Wu, 2013) and this could mean that these are the areas just like Biosciences where technologies are widely embraced.

To summarise, the author identified several key observations relevant to each component of the TPACK framework:

1) Reasons for using particular technologies: A discussion forum on the learning management system was the most widely used tool and student engagement was the driving influence behind using these tools. Lecturers also used tools that cater to different types of learners and their learning styles. These perceptions relate to student-centricity and reflect on the innovative use of digital technologies to cater to different learners.
2) Pedagogical Content Knowledge: Lecturers embrace problem-based learning, inquiry-based learning and constructivist learning as pedagogies for 21st century learning. These pedagogies allow for engaging with the content at a deeper level and promoting higher-order thinking skills. Survey results reveal limited interest among lecturers in using collaborative learning, informal learning methods, personalized learning, and flipped learning. These findings generate the need to look at different ways of introducing personalised learning through informal methods. With the use of emerging technologies, cultural shift and flexible curriculum there is a potential to enhance 21st century learning. Providing learning opportunities to collaborate with others within problem-based learning and enquiry-based learning can eliminate the resistance towards collaborative learning to some extent.
3) Technological content knowledge: A wide range of technologies were used especially in understanding abstract phenomena which is central to Biosciences learning. A better understanding of how technologies can be used innovatively to suit other disciplines is essential.
4) Technological pedagogical knowledge: Participants used technologies to understand cognitive, social, and behavioral aspects of student learning. To that end, a discussion forum was commonly preferred. The knowledge of innovative technologies and pedagogies can help academics to improve student learning. Although technology has been related to functional fixedness, lecturers need to rethink innovative ways of using technologies to customize pedagogical purposes (Koehler et al., 2013).

Recommendations

This study captures academics' perspectives on various technologies and pedagogies used to enhance 21st century learning in higher education. It is worthwhile understanding the rationale behind this perspective. How do lecturers know that these technologies and pedagogies best suit to address teaching and learning purposes? Probably, this information can be derived from personal experience, student feedback, grades/course outcomes, and monitoring engagement analytics. Further research is recommended to evaluate how participants know technologies and pedagogies best suit the purpose. Additional perspective from students' point of view on technologies is suggested to complement the findings of this study.

Study Limitations

With a small number of participants completing the survey, the likelihood of generalizing the findings of this study is limited. Besides, the majority of the participants belonged to biosciences department thereby limiting interpretations to other disciplines. Time constraint could probably also have limited the participation of respondents as the survey was open only for one month duration of time. Despite these limitations, the results identify various technologies and pedagogies for 21st century learning and consider the TPACK framework as an effective tool to develop teaching and learning skills.

Conclusion

This research investigated the role of technologies and pedagogies for 21st century learning from academics' perspectives. Our findings reveal a wide range of technologies and pedagogies are being embraced at Endeavour College of Natural Health. The TPACK framework provides a useful tool to gauge the learning environment. The framework highlights a complex interaction between technology, pedagogy and content knowledge and allows educators to use innovative technologies and renovation to contemporary teaching practices. The shift towards digital pedagogies in higher education is looking to contribute to the development of 21st century competencies and skills thereby preparing learners to face global challenges in the current knowledge age. The literature review showed some academics prefer technologies over pedagogies while others place pedagogies above technologies. This study supported the dynamic influence between the three components of the TPACK framework: content, technology and pedagogy. To educators, the TPACK framework serves as a lens through which teaching practices can be viewed and reflected upon thereby making the learning environment more conducive to student learning. This study provides the rationale for providing teachers with further training in the TPACK area.

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Corresponding author: Tirtha Goradia
Contact email: tirtha.goradia@endeavour.edu.au

Artificial Intelligence and the Student Experience: An Institutional Perspective

Kriti Khare
University of Alberta, Canada

Brian Stewart
University of Eastern Finland, Finland

Anshuman Khare
Athabasca University, Canada

Abstract

The paper outlines the potential for Artificial Intelligence (AI) to positively impact student success. This will be approached from a student life-cycle perspective, taking an integrated view of the student experience and identifying where AI can be most beneficial. Current usages of AI in education will be considered, in addition to those being experimented with and those still being considered. The paper will view the adoption of AI in education from a comprehensive perspective, considering technological, social, political, economic, cultural and ethical factors, providing a frame for understanding of the benefits and constraints of the most intelligent of information technology in the educational realm.

AI has started to emerge in educational institutions in the form of chat bots that are being used to provide student services as well as providing learning supports. Automated paper grading has started to be used, while academic advising and assessment are being trialed.

Keywords: higher education, artificial intelligence, Student Experience Practitioner Transitions frameworks

Artificial Intelligence (AI) has been increasing in its use in our everyday lives spanning a broad swath of uses ranging from personal assistants, purchase reference and prediction, smart homes and cars, fraud detection, online customer support, and even assisting personal relationships. This increasing use is fueled by the use of machine learning, computer modelling, and algorithmic creation enabled by ever bigger data sets combined with ever more capable technological capabilities driven by Moore's Law (Schaller, 1995) and Metcalfe's Law (Hendler & Golbeck, 2008).

The upward and accelerating trajectory of AI, encapsulated in the concept of the singularity, has drawn both excitement and concern from scientists, economists, and political and business leaders. The largest fear is that AI will outsmart its creators allowing the machines to turn the tables and become the masters, using our psychology to program our behavior. Further disquiet exists with respect to ethical considerations (Moore, 2006), governance of appropriate usage (Khatri & Brown, 2010) and to instances where programming bias have been shown to exist in early deployments of the technology (Devlin, 2017). These concerns are valid and remain to be addressed, however it is not our intention to pursue these here. We are viewing real applications of AI to education that are practical and achievable in the near term. More broad-based sociopolitical and economic issues are not discussed in this paper. Nor are implications for the curriculum and the almost certain requirement for the incorporation of AI literacy and information accuracy into all disciplines, lest intellectual laziness yield an unverified trust to systems that were based on their creators' assumptions.

The student higher education experience can be considered as a series of interdependent, overlapping, but not necessarily sequential, phases. This life-cycle approach is often used by administrators to manage student life as it distinguishes the critical elements of experience allowing the design and delivery of focused administrative services. The student lifecycle in higher education is defined as the journey of the student from first contact with an institution through to becoming an alumnus. The ultimate goal of a student is academic achievement accompanied by self-development through the academic experience. The academic success of students, however, relies on a composite of all aspects of the student's life. These other aspects include mental welfare and support, social interactions, sports and physical health, effective life balance, all of which contribute to the experience the student has in their higher education career (Morgan, 2013).

Applying a technology into a complex environment, particularly one as traditional as higher education, is a very challenging endeavour. As with many technologies, the key question is where to start, what use case would provide a fair test of the technologies capabilities? The purpose of this paper is to address this by providing an approach for the coherent adoption of AI into higher education institutions to lessen both the cost and time for its benefits to be available. The use of the student lifecycle and the grouping of activity sets creates target groups for experimentation and piloting within definable and accepted domains, allowing for effective hypothesis testing, collaboration and comparison with other institutions. While not wishing to underestimate the degree of difficulty such a shift may incur, it is reasonable to suggest that such an approach will improve the rates of early adoption and the speed to production.

One model developed to use this framework to understand the student journey, outlining the different stages that a student transitions through during their academic career, is the Student Experience Practitioner Transitions (SEPT). The model was developed to educate and guide practitioners about the various kinds of supports students need at each stage (Morgan, 2013).

In this article, using the Student Experience Practitioner Transitions (SEPT) model developed by Morgan (2013) as a basis, five potential areas in the process where artificially intelligent systems can be incorporated are analyzed (Figure 1). The functionality that these systems will perform, the tasks they would take over from the professors, teaching assistants and support staff, as well as related research, are discussed.

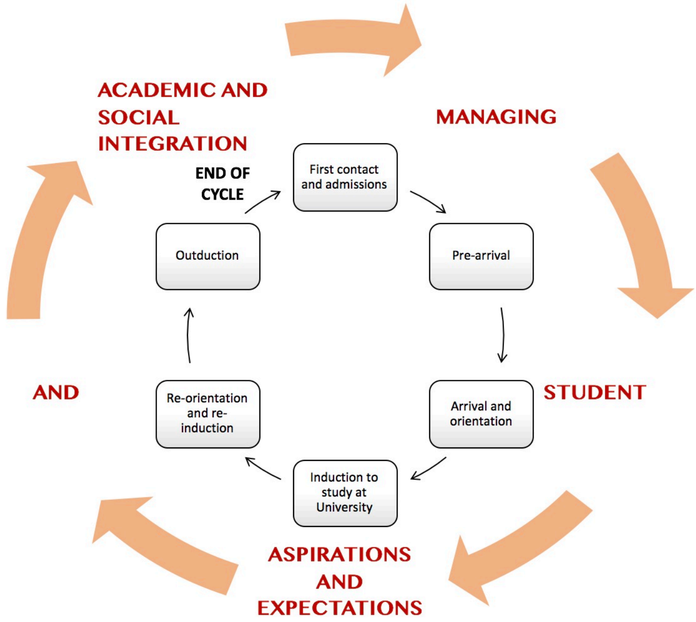

Figure 1. The Student Experience Practitioner Transitions (SEPT) framework (Source: Morgan, 2018)

The Student Experience Practitioner Transitions model has six stages of student life, each stage examining the unique position of a student at a certain point of time in his or her higher education (Morgan, 2013). The stages can be summarized as follows:

1. First Contact and Admissions – At this stage, the student makes an application to an institution based on his/her interests.
2. Pre-arrival – The student has been accepted to a program and any other requirements must be completed before the student arrives to embark on the course of study, such as receipt of final transcripts.
3. Arrival and orientation – Introduction to how the degree will be completed and getting used to campus life.
4. Induction to study – The first year of education when the student is introduced to coursework.
5. Reorientation and induction – gaining new skills as one progresses through their degree by taking advanced courses.
6. Outduction – entering the job market.

By viewing the student experience as a journey consisting of integrated steps one can use AI to analyse the steps and determine interdependencies between them to develop an integrated model of student behaviour. This model can greatly assist the understanding of behavioural determinants that impact students throughout their lifecycle. It further provides a classification for data sets that are available for model and algorithmic development.

The Artificial Intelligence Process

AI is a broad field that is comprised of many disciplines including computer science, statistics, linguistics, psychology, and decision science. It is essentially concerned with getting a computer to replace human intelligence in assigned tasks. Given the breadth of the field it is not surprising that there are quite a few definitions of AI. In addition these are non-constant as the capabilities develop. What was once considered AI begins to be seen as algorithmic development or big data analytics. A commonly accepted breakdown is to view AI as the overarching rubric which encompasses Machine Learning, which further encompasses Deep Learning. Rich and Knight (1991) state that "Artificial Intelligence (AI) is the study of how to make computers do things which, at the moment, people do better" (p. 3).

The definition of Artificial Intelligence, as stated in the first Volume of the Handbook of Artificial Intelligence is that "Artificial Intelligence (AI) is the part of computer science concerned with designing intelligent computer systems, that is, systems that exhibit the characteristics we associate with intelligence in human behavior - understanding language, learning, reasoning, solving problems, and so on" (Barr & Feigenbaum, 1981, p. 3). This definition is appealing, as in this paper we are imagining a system that can correlate data from different sources and present options and pathways to students based on their interests and eligibility, similar to a human counsellor. For the propose of this paper we take AI's meaning in the broadest sense, any use of a computer to replicate or substitute human intelligence to provide insights through the application of various machine enabled analytical processes to large data sets. Insights from Artificial Intelligence are only possible when data is available related to the sought for insight. This data may be collected by surveying people, gathered from people completing tasks, automatically generated and stored by a system in log files, entered in by an analyst, etc. Data may be structured, always in a particular format e.g. form entered data; semi structured, complying to a structure e.g. emails; or unstructured, where it does not comply to a given structure e.g. photographs. The latter two require reprocessing to be usable. After looking through all the data that is available and identifying the sources that would be helpful, this data has to be transferred and stored in a database or on a server, making it available in a format that the AI algorithm can process. Once the algorithm processes the data, insights can be obtained. Figure 2 describes a very simple and generic model: Data Generation – Data Storage – Data Processing – Actionable Insights.

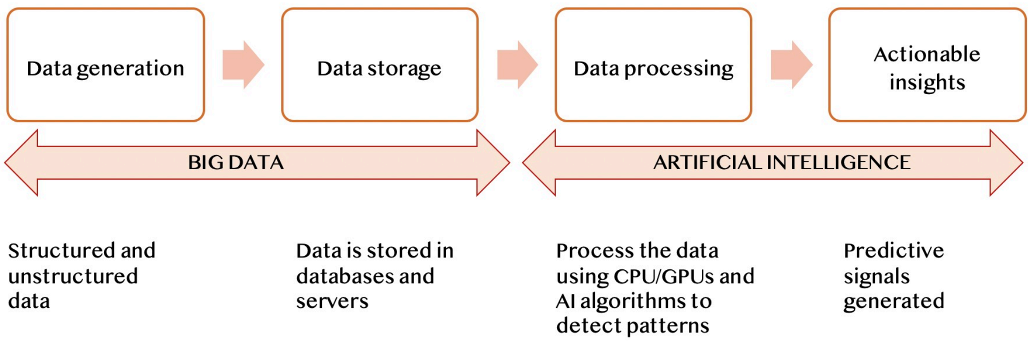

Figure 2. A simple AI process

Based on this Input-Process-Output model, data has to be collected and made available in a form for each stage in the Student Lifecycle, that the AI program can process and then yield insights that the student and organization can act upon. In the next sections, possible places where AI insights would be helpful are reviewed and a reference grid shows a high-level data to lifecycle stage mapping, articulating the data needed and the potential constraints and benefits of applying AI at each stage.

Incorporation of Artificial Intelligence at the Classroom Level

The mechanics have to be explained here and then the experience. The student would first interact with the system and input their interests, performance in studies to date, work experience, amongst other information. The intelligent system would then be able to provide a listing of the programs that the student is eligible for at the institute. If this system is utilized by more than one institution, programs across institutions might be suggested to the student as well. Possible pieces of information that could be utilized to train such a system could be the information from current students who are pursuing a program at the institution, their interests, the programs that they might have considered before pursuing the one they are in as well as career prospects. Similar data may be collected from alumni, noting the career that they are pursuing.

Once the student decides on a program of study and is accepted, the system would be able to show the student possible scholarships, volunteer opportunities, as well as present program specific information about preparing for the first day, book a tour of the campus, residence services, library services, potential student clubs (based on the interests that the system is already aware of), time scheduling, and so on. This would potentially cover the second and third stages of SEPT.

After classes have been selected and a term has been successfully completed, the system would be able to offer more refined job and volunteer opportunities based on the skills that the student has learned as a result of this education. Sweeney, Lester and Rangwala (2015) and Sweeney, Rangwala, Lester and Johri (2016) cited in Khare, Lam and Khare (2018) "predict whether the combination of courses that a student is taking in the current term would overwhelm the student. Thus, their research gives insight to students about courses they are taking, to counselors who advise the students about the course load and to instructors on considering differing course combinations" (p.43).

This would be an intelligent system that knows what the student is studying in all courses, the deadlines coming up as well the next set of courses that would become open to the student if s/he does well in his/her current set. This would integrate data from the various courses and the database of course dependencies to show the student possible what-if schedules for next term and year, one that can be changed according to interests and constraints facing the student. The system would also be able to analyze integrated data from the numerous sources to present the student his/her best options (Woolf, Lane, Chaudhri, & Kolodner, 2013). This also relates to the field of learning analytics and student competences and skills. Zhang and King (2016) analyse the order in which questions should be presented based on the knowledge level of the students. This can be further applied to the skills that courses teach and other courses require.

By keeping track of the time commitments of the student based on selected courses, volunteer work and part-time job, the student would have a more comprehensive idea of how their time is being spent and if they can take on more work. Woolf et al (2013) elaborate on the 21st century skills that artificial intelligence should work to address. These include self-direction and self-assessment. With information organized in a coherent way and presented such that only eligible options are shown, a student would be in better control of making choices that lead to the success he desires.

Intelligent systems make it possible for students to build a schedule for the term, while at the same time presenting financial aid and volunteer opportunities tailored to them for which they are eligible. This would reduce the number of human hours spent in counselling students regarding the courses they are eligible for as well as reviewing scholarship applications because the students would only be able to apply for the ones they are eligible for.

The Outduction of a student at the end of their course of study requires students to make a choice. Some students will seek to continue studying by taking another degree or pursuing an advanced degree. AI systems can provide guidance from their academic record as to a preferred course of study. Most students will want to move on to the workforce to start their careers. AI can assist students by providing career tools to align their aspirations with the pathways to get there. Further AI career coaches can provide personalized advice based on the student's history, experience, locational choice, skills combined with career requirements to supply students needed further study tracks and possible staging and development paths. IBM's AI powered Blue Matching system is an example of a job matching service that demonstrates the real potential here (Clegg, 2017).

All of the above are dependent on available and useable data. This is not a trivial requirement as most of the data will not be in a directly useable form and will need either significant reworking or will require to be newly gathered in the desired format. Machines, like humans, need information to learn from, they also need, at least with the present state of technology, humans to shape that data for them. While quicker when they have the appropriate data, available AI systems have yet to be able to effectively forage on their own behalf.

Forum Monitoring by Intelligence Systems

Forum monitoring offers another opportunity for AITAs to improve the efficacy of collaborative forums. Currently human Teaching Assistants (TAs) are asked to check the forum at least once a day such that all questions could be answered within 24 hours. The same rules are applied to emails and TAs are encouraged to ask the students to post a question on the forum if its answer would be helpful to other students.

Questions are often related to the concepts being studied in the class and the assignment. Thus, the scope of the questions is often defined. Using data from forum posts from previous iterations of the course, machine learning can be applied and trained to associate questions with answers. This reduces both response time (or eliminates it) and the effort of TA's to research and create an answer. If a set of resources are associated with each topic, it is possible to point out these resources to students, just like the TA would have done (Khare, Lam, & Khare, 2018). Algorithms can be used to time themselves for answering the student and if no answer is found or it is taking too long, a mechanism can be put in to notify a teaching assistant. Once the TA resolves the question, the algorithm may be trained further to answer it next time or to flag certain questions that must go to TA directly. Going beyond answering questions, reviewing the forum posts for the understanding of the students, using content analysis and text mining techniques can determine if the discussion coverage is as expected (Khare, Lam, & Khare, 2018).

Tutoring and Advising

The use of intelligent agents and chatbots are growing rapidly in use in consumer electronics and customer service. Commonly referred to as chatbots these devices use AI to provide context aware information to the user, usually in a relatively narrow range. The application of this technology to support students enables the potential for expanded one-on-one tutor engagement, not economically achievable in existing teaching models. These are being trialled in education, varying from providing administrative and service information to supporting academic study. A number of studies suggest that chatbots, also known as intelligent tutors or intelligent teaching assistants, are significantly beneficial to students and positively add to the student experience and probability of success. IBM Watson supported chatbots are being used in Deakin University (Deakin University, 2015) in Australia to provide student guidance to life on the campus and in the cloud, and at GeorgiaTech's online master's in computer science to provide teaching assistance. Both have proven very successful after initial training, due in large part to the question set remaining relatively consistent allowing AI to prove effective (Maderer, 2016). Georgia State University noticed that not all students who accept admission offers enroll in Fall. They called this phenomenon "summer melt" (Ravipati, 2017). They employed an AI chatbot called AdmitHub to significantly increase the number of students that enroll after admission by improving communication with students using text messages (Ravipati, 2017). Studies by Steenbergen-Hu and Cooper (2013; 2014) and VanLehn, (2011) have indicated that AI tutors are as good or better than human tutors, however the evidence is unclear, and the experimental designs used to date do not provide an unambiguous answer. Moreover, human to human interaction for teaching is unlikely to be replaced in the near term. As humans, we still need personal connections for inspiration, compassion, self-reflection, imagination and life context. Learning is every bit as much emotional and social as it is teaching technique and technology. The replication of intelligence by machines may not be matched by their abilities to emote or socialize, indeed the concept of artificial emotion seems to be a contradiction in terms. Thus, the ability of humans to express empathy and to provide emotional as well as intellectual understanding to form connections and form social bonds will ensure, at least for the near future, human advising and tutoring are superior supports for human learning.

Grading and Assessments

Many aspects of grading automation are currently in practice and are well accepted within the higher education community. In many instances logical rules and rubrics are used for grading and these can be taught to a program, such would result in a reduction in the number of human hours spent on grading. These are, in the main, straightforward tabulations of choice type questions, where there is a predetermined correct answer. Assessments and grading of less discrete answer sets, in particular long essay questions, are not likely to receive as warm a welcome by academics. Nonetheless AI is being applied to the grading of short and long essay types and is showing considerable success. The work done in this field includes automatic feedback. Zhang, Shah and Chi (2016) have worked on automatically grading short answer questions. Automatic Essay Grading is a growing field of research that aims to grade long essay questions (Page, 1994; Rudner & Liang, 2002; Chen, Liu, Lee, & Chang, 2010; Dong & Zhang, 2016). Recent work by Dong and Zhang (2016) elaborates the potential of deep learning algorithms to grade essays.

Christian (2018) formulated a rule-based system to evaluate C++ programs in the early stages when a student is learning a new concept by grading and informing the student on where he is with respect to the solution and learning objective.

It is quite likely to see AI aided formative assessment technology being employed as this aids academic productivity and assists students in their development of understanding and mastery of the material. Chen, Breslow and DeBoer (2018) analyzed a blended learning environment and the effects of immediate corrective feedback on student behavior. They found that the feedback led to reflective studying, and higher performance was predicted for students who used the corrective feedback feature.

Delivering content based on the performance or understanding of the student

Adaptive learning has been much trumpeted over the years and was seen as one of the early benefits of online or computerised enabled learning. The use of games in education follows a similar pedagogical approach of uncovering within a dependent interrelated environment of knowledge objects or situations. Squire and Jenkins (2003) discuss the pedagogical potential of games. Polin (2018) elaborates upon the features of games that make them spaces that support learning. Lamb, Annetta, Firestone and Etopio (2018) provide insights into the kind of games – Serious Games, Educational Serious Games and Educational Simulations that have the most impact on students' cognition and behavior. However, the recent troubles of Knewton, one of the flagship companies in this area (Young, 2017), indicates that this is still an area that has yet to fulfil its potential.

Self-paced learning is where the program can judge when a new topic has to be introduced or an older topic has to be reviewed by the student. The models used by Intelligent tutoring systems would be helpful here to determine when a student has learned a concept and is ready to move on to the next one (Lin & Chi, 2016; David, Segal, & Gal, 2016). The data from assignments and practice questions as well as response time is often used to find the state of 'learned' and build a student model which represents the knowledge of students (Lin, Shen, & Chi, 2016). These systems provide feedback, timely guidance and explanations when students make mistakes (Shute, 2008). They keep track of the learning outcomes and are able to determine the content appropriate to the student's difficulty level (VanLehn, 2006). In this way, students' learning experience has a bigger focus than the lessons themselves.

Intelligent Tutoring Systems such as Carnegie Learning and Front Row have been tailored to school students. To the best of our knowledge, there are no cognitive tutors at university level. These could be used to supplement the understanding of students.

Augmenting this information about the student with 'smart content', Cram101, built by Content Technologies Inc., uses artificial intelligence to breakdown the textbook into smaller sections, including chapter summaries, practice questions and flashcards to form a 'digestible "smart" study guide' (Faggella, 2017).

AI applied to the classroom level can provide significant benefits which are even more telling in the online environment where the delivery of courses can be enhanced economically through AI enabled automation. The ability to provide responsive support to students on a consistent basis, although inferior to human interaction, is nonetheless superior to current online delivery models that normally have time limited support due to the cost of human TAs. Even moderate quality support that is consistently available is preferable to high quality support that is rarely available. Moreover, a human TA or professor can review and provide additional support to the AITA whether due to AI restrictions or by providing additional learning moments. The potential impacts on the online business model are substantial, by reducing the total cost of providing online courses, a significant lowering of tuition to students is possible. Such would allow greater access to secondary and tertiary education particularly in less economically advanced countries. Slightly ironic that artificial intelligence may be the key to growing global human intelligence.

Combining Artificial Intelligence with the SEPT Model

There is an iterative loop here as data generates insight creating the need for additional data that generates enhanced insight. It also can demonstrate the gaps in data for a given desired insight as well as potential insights from given data sources. By doing this we can show the potential for AI to provide benefit to learning and student success. Morgan (2013) identified five themes in the SEPT model – curriculum and assessment, pedagogy, support, finance, and employment. Table 1 is based on the data available from these themes and presents a further analysis of the data sources, possible insights, and barriers to using the data.

Table 1. Artificial Intelligence (AI) Lifecycle Matrix using SEPT framework

Question \Stage	First Contact and Admissions	Pre-arrival	Arrival and orientation	Induction to study	Reorientation and induction	Outduction
What data is available for each stage	Student interests Subjects taken by student Grades in subjects Degree applied for Courses to be taken in the degree Fee estimates Possible scholarships and financial aid Part-time work opportunities	Subjects selected by student to study – coursework Money management advice Financial support available Placement options Internships Volunteering opportunities	Subjects that make up the degree Assessments Money management advice Financial support available Placement options Internships Volunteering opportunities	Subjects being studied Assessments Money management advice Financial support available Placement options Internships Volunteering opportunities	Skills gained after a term/year of study Subject choices available Money management advice Financial support available Placement options Internships Volunteering opportunities Future job opportunities Professional development opportunities	Job opportunities Further study prospects Debt control Professional development opportunities Transitioning into a workspace
What are the sources of this data	Student application Reference letters for the student Previous examination results Career development system at the institution	Student profile Financial profile of student Scholarships applied for and rewards Career development system at the institution	Student profile Financial profile of student Scholarships applied for and rewards Career development system at the institution	Student profile Financial profile of student Scholarships applied for and rewards Career development system at the institution	Learning outcomes and competencies of previous courses Job profiles of graduates from selected degree Career development system at the institution	Requirements of graduate degrees student is eligible for Job profiles of graduates from selected degree Career plans
What systems does the information reside in		Student Information System Customer Relationship	Student Information System Customer Relationship	Student Information System	Student Information System Faculty databases	Student Information System

Question \Stage	First Contact and Admissions	Pre-arrival	Arrival and orientation	Induction to study	Reorientation and induction	Outduction
		Management System Faculty databases	Management System Faculty systems Residential database Student union systems	Faculty databases Residential systems Learning management system Student union databases Library systems Volunteer systems	Residential database Learning management system Student union databases Library systems Physical activity systems Volunteer systems	Faculty databases Residential database Learning management system Student union databases Career development system
What Insights can we develop for each stage	Degrees and Courses that match and best fit student's interest and likely success What-if Financial scenarios Optimal path to complete degree	Volunteering choice Optimal schedule to manage coursework, work and volunteering Steps to take to be successful in classes Career opportunities Residential choice	Time management Subjects to take Campus Orientation	Optimal study plan Resource suggestions and provision Study aides and course strategies Practice assignments Daily schedule management Time management	Optimal study plan Resource provision Study aides and course strategies Practice assignments Schedule to manage coursework, work and volunteering Time management Career opportunities Job shadowing opportunities Projects/Workshop suggestions that would strengthen job prospects later Skills that are underdeveloped or need improvement Learning progress and success supports	Best fit Jobs to apply for Further job specific training opportunities Application deadlines for graduate programs Best fit International study opportunities
What barriers to usage and value exist	Privacy of student information Maturity of IT systems Data accuracy, availability and access Institutional culture and policies Lack of systems integration Lack of data sharing agreements with external organisations Lack of appropriate data Lack of understanding of AI					
What enablers to usage and value exist	Data governance to develop and ensure consistent data architecture in combination with standardized data definitions Identification of additional key data sources that bear on student experience Policy review of data sharing to facilitate and frictionless access Integration of data and applications to provide real time data across the enterprise					

Question \Stage	First Contact and Admissions	Pre-arrival	Arrival and orientation	Induction to study	Reorientation and induction	Outduction
Where can it go next	Enhanced engagement of potential students through intelligent selection and information provision to select institutions, programmes and career paths	Augmented reality campus guide Campus life planner Residential planner Social life assistants	Data sharing across the institution to provide insights into success patterns Learning materials agent to reduce costs	Real time data availability for improved decision making on programmes and course selection	Study buddy agents Virtual and augment reality learning resources	Integration with work placement dbases to provide best-fit opportunities for job placement and career advisement

Conclusion

The two main bodies of systems analyzed in this paper were those of the student lifecycle and the learning management system. While the lifecycle management systems keep track of overall student progress, the courses they have taken, venues of financial support, volunteer opportunities and schedule management, the learning management systems are focused on the academic progress of the student. From this it is seen that student lifecycle management relies more on the administrative staff while learning management systems are supervised by the academic staff at a higher education institute.

As with all innovations their adoption is not an either-or, but a blending and integration of the strengths of both the existing and the new to provide a superior capability. If we, therefore, assume that we can combine activities currently managed by these systems with an intelligent system, we can begin to redesign a new system of education, one breaking out of the traditional roles of professors, teaching assistants and support staff, making them facilitators of knowledge and managers of the new systems. At the classroom level, in many cases, it will free up time to use the in-class time in a different way. The concept of flipped classrooms is where students study the assigned material at home and come to the class to discuss it. This might be supplemented with learning activities in class such as discussing complex concepts or examining real-world examples. On the other hand, at an administrative level, work of support staff may be reduced with regards to providing counselling to the student about potential next steps as the student would already have access to the courses they are eligible for, credits they can take from other universities, the career venues and graduate programs open to them based on his/her current performance and volunteer opportunities to augment his/her resume, to name a few areas. The advantages of such an integration of the student lifecycle and learning management systems is to give students the choices and options, right for them, at the right time in their higher education journey.

Another system using artificial intelligence which we did not explore here is at the academic department and faculty level for curriculum design. Such a system would analyze the needs of the discipline, trends in the current job market and research as well as the new knowledge skills that graduates require for being successful. This information would feed into design and development of new courses and programs, enhancing student experience by increasing their employability.

This paper has attempted to show that AI is and can be a significant aid to all aspects of the student experience and to the organisations, structures, processes and people that make up educational systems. It further provides an architectural approach that is a coherent representation of real experience, which provides a context for experimentation and the development of a referenceable literature. It does not try to make the case that AI is superior or equal to human equivalents, rather it attempts to demonstrate the benefit of synergistic integration of both forms of support for student success, allowing each to support the other to provide what they are best at. By so doing all stakeholders benefit and the student experience is improved with the expectation that student success increases *pari passu*.

Finally, we need to be aware of techno-solutionism to address wickedly complex problems, but we should also explore its capabilities to find the best-fit for its application and benefit to an increasingly expensive and technology resistant system. The pace and depth of adoption will depend not only on the continued growth of AI capabilities, but also on the opening and sharing of data and the acceptance of a highly conservative system unused to collectively integrating technology into its corpus. By providing an adoption framework this paper desires to enable a more structured and efficient introduction of AI technology into Higher Education. One that can benefit students, faculty and administrators through an enhanced user experience that improves the ability of educational institutions to deliver on their core mission of teaching, learning and research.

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Corresponding author: Anshuman Khare
Contact email: Anshuman.khare@fb.athabascau.ca

Teaching Them before We Teach: The Effectiveness of Conducting Classroom Experiments before Teaching the Underlying Theory

Raymond Li
Hong Kong Polytechnic University, Hong Kong

Tina Wong
Hong Kong Polytechnic University, Hong Kong

Abstract

This study examines the effectiveness of classroom experiments conducted before the relevant theories were taught. The experiments were used to provide students with first-hand experience of decision-making under various rivalry settings and to demonstrate several key predictions of oligopoly models. Statistical methods were used to analyze the effectiveness of these experiments in helping students master the concepts covered by the experiments. In general, students had a positive experience in the process and they found the experiments useful in stimulating their interest and helping improve their understanding of the relevant theories. Statistically, students who took part in the experiments performed significantly better in an exam question on oligopoly markets.

Keywords: economics education, classroom experiments, prior knowledge, decision making, oligopoly model, treatment-effect model

Introduction

Economics is a discipline that can be characterized by rigorous theories developed to explain the behavior of economic agents or businesses. These theories can be evaluated by observation of actual human behavior or empirical analyses involving the use of relevant data. However, since economic decisions are usually made in a non-laboratory environment, it is difficult to evaluate these theories directly. To address this problem, economists have designed experiments that can be used to collect economic data under a controlled environment. These experiments can be useful in testing the validity of economic theories, as well as in teaching and learning. Learning is more effective when students can relate to what they are being taught. Oftentimes, students fail to understand economic models because they lack the first-hand experience and/or prior exposure to the context addressed by the models. The problem gets worse when the models are mathematical and students' attention gets diverted away from the economic reasoning behind the models. To help students understand these models, classroom experiments have been increasingly adopted by instructors. As noted by Neral and Ray (1995), classroom experiments not only provide students with concrete examples of the phenomena that the economic theories attempt to describe, but also the experience which can be related to particular aspects of the theories.

The effects of classroom experiments on student learning have been examined by various studies in the economics education literature. To our knowledge, in all but one of the existing studies (namely, Cartwright and Stepanova, 2012), classroom experiments were introduced *after* a relevant concept was taught. This approach helps reinforce concepts by allowing students to apply what they have learned in a (semi-)controlled environment. The aim of our research was to examine the efficacy of classroom experiments in improving student learning outcomes when the experiments are conducted *before* the relevant concepts are covered. We postulate that by giving students first-hand prior experience on the subject matter, it becomes easier for them to learn as a first-person rather than a third-party, and this enables students to master the models more effectively. We believe the results of this study will enable the development of a better understanding of the experiential learning pedagogy.

Our study began with an optional session of a computerized classroom experiment, where students were required to compete against the others in the classroom by making a series of business decisions in order to maximize their profits. The market conditions were known to the students, but relevant theories of this market setting were not yet covered in the lecture. Students' feedback on various aspects of the experiment were collected through a questionnaire and their course results were used to examine the effectiveness of our classroom experiment on improving students' learning outcomes. An endogenous treatment-effect regression model was used to mitigate the potential bias that voluntary experiment participation may exert on our regression results.

In the next section, we review the literature on experiential learning and the application of experimental learning in economics. Section 3 describes our experimental set up and some preliminary data on student learning outcomes. Section 4 contains the details of our regression analysis and Section 5 concludes.

Literature Review

Overview of Experiential Learning

The development of experiential learning began in the 20th century. Dewey (1916) first defines experiential learning as "learning by doing". Hoover and Whitehead (1975) later elaborate that this learning approach is self-directed which includes a high level of active involvement and participation. According to Kolb and Kolb (2005), the primary focus of experiential learning is transformation of experience to knowledge. Knowledge is constructed through learners' experience, reflection and thinking. Experiences serve as the basis for participants to reflect and think, and these reflections offer new implications to them. Kolb and Kolb (2005) point out that experiential learning is a process that draws out students' ideas about a topic and allows them to integrate new experiences with existing concepts.

Wolfe and Byrne (1975) suggest four major tasks of experiential learning, namely, design, conduct, evaluation, and feedback. Design consists of specifying learning objectives, producing activities for students and identifying factors affecting student learning. In order to create a favorable learning environment with structured learning experience, conduct is the following task which involves controlling the design. While evaluation is important by offering opportunities for participants to express what they have benefited, feedback is a continuous monitoring process aiming to improve the learning approach further.

Classroom experiments offer students with opportunities to discover economic concepts by themselves (Emerson, 2014). By engaging with the learning materials more fully, students are able to think deeper about the subject matter. This learning approach enhances students' learning motivation because students will engage with the subject matter more as they must apply theoretical knowledge to conduct experiments for solving real-life problems (Hawtrey, 2007). In addition, experiments can significantly raise the degree to which students found the course stimulating (Ball, Eckel, & Rojas, 2006). Personal skill development is also emphasized under experiential learning (Egbert & Mertins, 2010). Students are encouraged to explain subject matters to each other or work effectively and support each other in teams. As a result, they can develop self-organization skills and team spirit through experiments. The benefits obtained from this learning experience will last beyond the lesson.

According to Egbert and Mertins (2010), instructors can also gain from experiential learning by enjoying teaching more. Classroom experiments serve as a good starting point for problem discussion, enhance instructor-student interactions, and help inspire students to understand theoretical concepts through discussions about the experiments. It is rewarding for instructors to see students being intrinsically motivated with their course design. By arousing students' intellectual curiosity and having enjoyable interaction with them, instructors' satisfaction from teaching will likely be raised.

Despite the merits mentioned above, the challenges of this active learning approach should not be ignored. Unlike traditional instructional approach, it is time intensive for the instructor to plan and prepare courses with experimental learning. Besides, uncertainties always exist when conducting experiments and the results of the experiments may not be predicted and controlled easily by the instructor. Emerson (2014) recommends running trials of an experiment so that the sample results will be useful for understanding the pitfalls that may arise. In light of this, instructors are advised to state the solutions to deal with those pitfalls in their manuscript in advance. Moreover, students may complain that learning with experiments is time consuming as they are required to do more work. As noted by Egbert and Mertins (2010), this is true as students often focus only on examinations. Thus, it is essential for students to understand the importance of learning informally through this active learning technique. In order to motivate students to be passionate in classroom experiments, Emerson (2014) encourages instructors to develop classroom experiments on those topics where students would enormously benefit from seeing the concept in action.

Previous Studies on Experimental Learning in Economics

According to Emerson and English (2016), the existing literature on the efficacy of experimental learning can be classified into two categories. Studies in the first category focus on particular experiments and examine the effects of these experiments on student learning in related topics. Frank (1997) and Gremmen and Potters (1997) are two major previous studies under this category. Frank (1997) examines the impact of a simple tragedy of the commons experiment while Gremmen and Potters (1997) study the effects of an international economic relations simulation game on student learning. By comparing the assessment marks, both studies found that students who engaged in or observed the experiment performed better and learned more about the economic model than those who are not involved in the experiment. The experiments in both studies were conducted after the delivery of a relevant lecture.

Studies in the second category examine whether exposure to the experimental learning pedagogy improves students' overall course achievements. In general, these studies are broader in nature and conduct experiments on an extensive range of economics topics. The empirical findings under this category of research are mixed. On one hand, Emerson and Taylor (2004), Ball et al. (2006) and Dickie (2006) found that experimental learning improves students' examination performance in general. In all three studies, students were divided into control groups and experiment groups. Traditional lectures or seminars were conducted in the control groups while the experimental learning approach was adopted in another group. Emerson and Taylor (2004) administer experiments covering topics such as supply and demand, sales taxes, externalities, monopolies and adverse selection while Ball et al. (2006) employ experiments relating to taxes, public goods, tragedy of the commons and other economics concepts. Dickie (2006) conducts experiments relating to the topics of comparative advantage, demand and supply, sales tax and effects of minimum wage. Regression models were used in all these studies. Emerson and Taylor (2004) identify student learning as a function of student specific characteristics, such as aptitude, education background and teaching methodology. Ball et al. (2006) focus on analyzing final examination performance and include year of study, gender and whether students have taken economics in high school as the independent variables in their study. Dickie (2006) measures how classroom experiments with and without grade incentives affect learning of microeconomics and supplements comparisons of treatment means by collecting additional data such as student's cumulative grade point average (GPA), composite score on the American College Test (ACT), number of semester credit hours passed, race, and gender. All three studies documented that students participating in the experiments perform significantly better in the examinations than those in the non-participating group. More recently, Rousu et al. (2015) examine whether or not providing monetary incentives will enhance students' examination performance. They find strong evidence that students who played a classroom experiment game with real monetary consequences eventually performed better in the examination than those who played a hypothetical game and those who did not play at all.

On the other hand, Cardell et al. (1996) were not able to find evidence on improved student achievement through experimental learning. They employed computerized experiments relating to demand and supply, public goods and income redistribution. Including students' gender, GPA, prior experience in taking economics course, attendance rate, Scholastic Aptitude Test (SAT) scores, age and ethnicity as the independent variables in the regression model, there is no statistically significant difference between students from the experiment and control groups in the performance of the Test of Understanding College Economics (TUCE). However, Cardell et al. (1996) noted that their results are preliminary because there is no direct control for sample selection and variations in the behavioral impact of instructors cannot be fully controlled until the experiment is completed.

Durham et al. (2007) found mixed results on the influence of experimental pedagogy on students' examination performance. They include class size, age, gender, ethnicity, ACT exam score, GPA, attendance rate and students' major in the regression model. Their research shows that students participating in experiments perform better than the non-participants in questions illustrating the concepts of demand and supply, cartels, resource allocation and public goods. However, participants were outperformed by non-participants in areas of monopoly and diminishing marginal utility.

While the majority of research studies on classroom experiments are focused on university education, Eisenkopf and Sulser (2016) focus on high school students in the German-speaking area of Switzerland. They randomly assigned students into an experiment and a conventional teaching group. Data suggests that their classroom experiments did not offer a significant benefit to students in terms of average test scores. The authors point out that this lack of significant benefit can potentially be due to the fact that economic theories taught at the high school level are generally less abstract, hence limiting the effectiveness of classroom experiments.

Instead of comparing student achievements with and without the use of experiments, Yandell (2004) and Cartwright and Stepanova (2012) studied other aspects of experimental learning. Yandell (2004) examines the influence of the number of experiments on student achievements. Experiments adopted in this study cover topics such as double oral auction, production function, public goods and prisoners' dilemma. A comparison of the examination performance between students who are exposed to only two sets of experiments and those with six sets reveals no statistically significant difference. It is concluded that additional experiments do not pose positive impacts on student achievement. Cartwright and Stepanova (2012) compare the performance of students who attended and/or wrote a report on an experiment versus those who did not. They observed a 40-60% improvement in students' score in a classroom experiment-based test question if students had written a report on that experiment. Their findings illustrate the benefit of integrating classroom experiments with some form of assessment.

Our study falls into the first category as classified by Emerson and English (2016). We focused on one set of oligopoly market experiment and study the effectiveness of the experiment on improving students' learning outcome. But unlike Frank (1997) and Gremmen and Potters (1997) in which the experiments are conducted after the relevant lectures, we conduct the experiments before the relevant lecture is delivered.

Experimental Design and Data Description

Background and Experimental Design

This study was implemented on a calculus-based intermediate microeconomics course offered in the Spring semester of the 2015-16 academic year at the Hong Kong Polytechnic University. The enrolment size was 59, with students either majoring in Investment Science or minoring in Business Economics. As this course is at the intermediate level, all students have prior knowledge in economics. Similar to the market structure curriculum of most microeconomics courses, perfect competition and monopoly models are covered before oligopoly models, such that students have a firm grasp on the concept of profit maximization before the introduction of interdependency between firms. An experiment session was inserted in the teaching schedule between the monopoly and oligopoly models. The session was pre-announced and held during a normal class time. Attendance at the session was voluntary, just as class attendance was voluntary.

Two experiments were adopted from Economics-games.com, an online platform offering free educational games and experiments for teaching economics. One was based on the Stackelberg model and the other on the Cournot model. Each student used an individual electronic device (mobile phone, tablet or laptop computer) to access the experiment system. In order to keep track of students' decisions and participation, they were required to log into the system with their student ID. They were then paired up with an unknown counterpart in class, whom they had to compete against. Instructions were shown to students before each experiment, outlining the setting of the market, the objective (i.e. profit-maximization), and the choice variable. In both experiments, the market demand function and marginal cost of production were known to every participant. Students were required to submit a production quantity decision to the system, either in turn (Stackelberg game) or simultaneously (Cournot game). After receiving all the decisions, the system calculates the profit earned by each participant and a leaderboard was projected on the screen so that everyone knows the outcomes. Each game was repeated five times. To encourage serious participation, a special bonus mark was given to the top three students who achieved the highest cumulated profit in each set of experiment.

Students were asked to share and review their experience after each series of experiment. Unsurprisingly, all top-performers had factored into their decisions the expected behavior of their rivals. This outcome allowed the instructor to stress the importance of strategic behavior in oligopoly markets. As the experiment session was held before the discussion of the relevant models, it gave students a first encounter with the context of the oligopoly models. This helps pave the way for the actual discussion of the actual models because students can relate to the models with their personal experience. It also helps arouse students' interest and increase their motivation in learning the models, as they would like to know how they could have achieved better results.

Questionnaire Results

At the end of the semester, students were required to complete a questionnaire evaluating the characteristics of the experiments and the perceived effectiveness of the experiments in helping them meet the learning objectives. The scope of this research and the use of students' data (including questionnaire feedback and course results) were explained clearly to students in the introduction of the questionnaire. Students were given the option to leave the questionnaire blank if they do not wish to have their data used for this research. All questionnaires were collected by a student representative and the questionnaires were kept in the School's administration office until final examination results were finalized and released.

Students were required to indicate on a five-point scale their opinion towards various statements about the experiment (1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree). Students were generally positive to both the experiment setup and the associated learning experience. The arithmetic means of the responses to the statements range from 3.97 to 4.17. The primary objectives of the experiments are to stimulate students' interest in the subject matter and help students understand the relevant course content. As reported in Table 1 and Figure 1, 80% or more of the students agreed (i.e. giving a rating of 4 or above) to the questionnaire statements addressing these two objectives (S3 and S4). Also, most students can see the relevance of the experiments to their study (S5). Overall, students were positive towards the learning experience provided by the experiments, with over 70% of students agreeing to statement S6.

Table 1. Questionnaire statements and mean score

Statement	Mean
S1. The experiment requirements are easy to understand.	4.09
S2. The competitive nature of the experiments increased the level of excitement.	4.17
S3. The experiments help stimulate my interest in the subject contents.	4.03
S4. The experiments enhanced my understanding on how competitors interact in various market structures.	4.06
S5. I can see the relevance of the experiments to my studies.	4.09
S6. In general, the experiments have provided me with valuable learning experience and knowledge in the topic concerned.	3.97

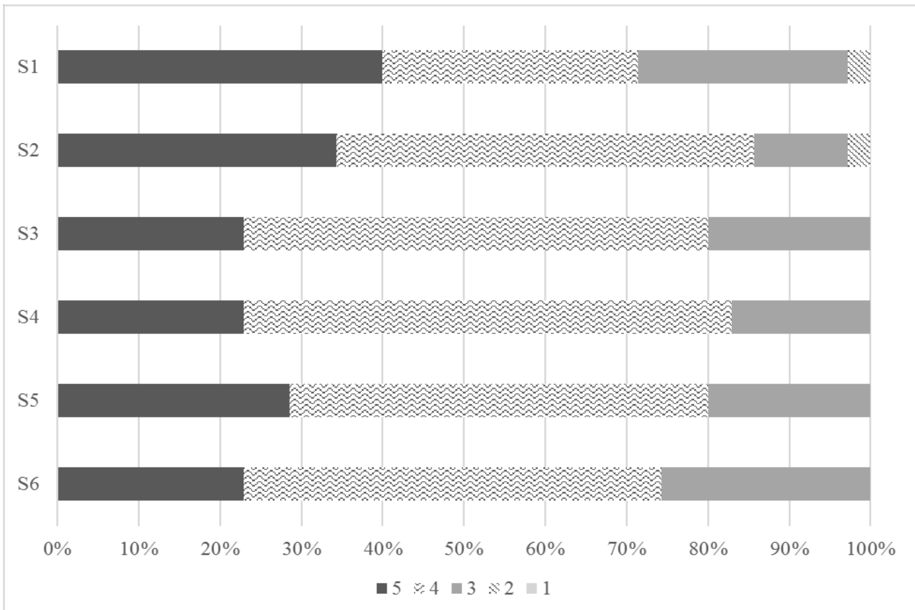

Figure 1. Percentage distribution of questionnaire responses

Impact on Learning Outcomes

We postulate that participation in the experiment session helps improve students' understanding of the oligopoly theories and subsequently improving their learning outcome.

In this study, we quantify student learning outcome through a final examination question devoted to oligopoly models. All questions in the final exam were compulsory and the oligopoly question accounted for 20 out of 100 points of the examination. Figure 2 compares the major assessment performance of students who participated in the experiment (*EXP*=1) and those who did not (*EXP*=0). We can see that the experiment group performed noticeably better in the mid-term test (*MT*), overall final examination (*EXAM_TOT*), questions in the final examination addressing other topics (*EXAM_OTH*), as well as the oligopoly question (*EXAM_OLI*). Table 2 summarizes the results of four t-tests of equal means on the assessment scores of the two groups. According to the p-values for the two-sided tests, the null hypothesis of equal mean is strongly rejected at 1% significance for each assessment outcome. The same results hold irrespective of the assumption on equality of variance.

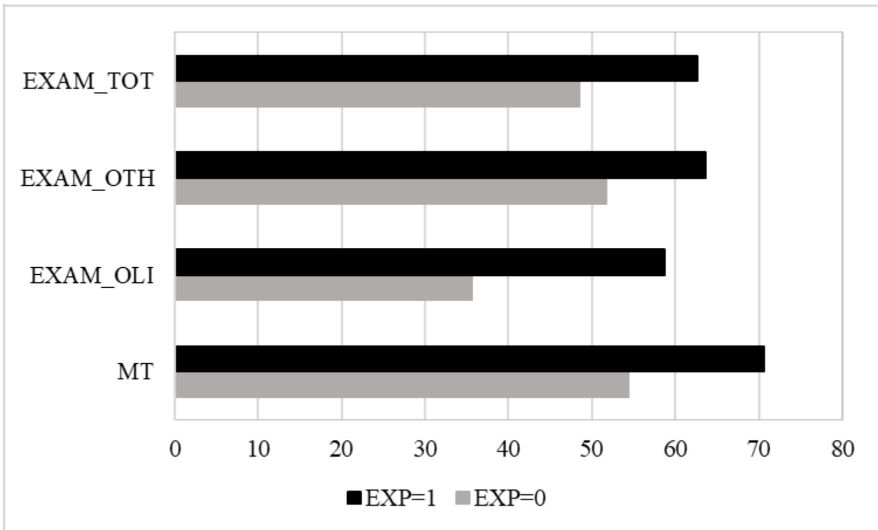

Figure 2. Student assessment outcomes

Table 2. Two-sample t-tests of equal means assuming unequal variances

	Mean	**Variance**	**Obs**	**t-stat**	**p-value**
MT					
EXP=1	70.629	283.711	35	3.665	0.001
EXP=0	54.417	275.123	24		
EXAM_TOT					
EXP=1	62.600	194.071	35	3.237	0.002
EXP=0	48.458	325.042	24		
EXAM_OTH					
EXP=1	50.857	116.773	35	2.856	0.007
EXP=0	41.333	186.841	24		
EXAM_OLI					
EXP=1	11.743	29.550	35	2.905	0.006
EXP=0	7.125	40.375	24		

The results in both Figure 2 and Table 2 apparently suggest that students who participated in the experiment session were the "better" ones in terms of their intellectual ability and/or motivation, because they performed significantly better in all assessment tasks. As a result, better performance in the oligopoly question, at least on its own, does not necessarily imply that the experiment session was beneficial to students' learning. However, on closer examination of Figure 2, we can observe a more pronounced difference between the mean scores in *EXAM_OLI* relative to that of the other assessments. The mean scores of the experiment group were 30%, 30%, 23% and 65% higher than the control group in *MT*, *EXAM_TOT*, *EXAM_OTH* and *EXAM_OLI*, respectively.

Econometric Model and Results

In order to isolate the impact of our experimental session on students' learning outcome, we further analyze students' score in the oligopoly question under a reduced-form education production function framework:

EXAM_OLI = f (student ability, study effort, learning attitude, experiment participation)

Since we do not have detailed and reliable data on students' ability, study effort and learning attitude during the semester, we use students' net continuous assessment score (= continuous assessment score minus participation score), *CA*, as a proxy variable to control for the effect of these factors on students' performance in the oligopoly question. Specifically, we anticipate a positive relationship between *CA* and *EXAM_OLI*. This yields the following basic regression model:

$$EXAM\_OLI_i = \beta_0 + \beta_1 CA_i + \beta_2 EXP_i + \varepsilon_i \quad (1)$$

where subscript i identifies the individual students and ε is an error term. Since participation in the experiment session was voluntary, students who participated were likely to be more motivated (and/or with better learning attitude). Therefore, experiment participation is likely to be endogenous. We accommodate this sample selection problem by estimating equation (1) as an endogenous treatment effects model (Maddala, 1983, ch.9), in which EXP_i is assumed to stem from an unobservable latent variable, EXP_i^*, that depends on students' class participation and overall performance during the semester. Experiment participation is modelled as follows:

$$EXP_i^* = \gamma_0 + \gamma_1 PART_i + \gamma_2 CA_i + u_i \quad (2)$$

$$EXP_i = 1 \text{ if } EXP_i^* > 0, \ = 0 \text{ otherwise} \quad (3)$$

where *PART* is a class participation score ranging between 0 and 10 to reflect a student's level of involvement in class and u is an error term for the treatment-assignment model. It is expected that both γ_1 and γ_2 are positive.

We estimate the endogenous treatment effects model with a one-step control-function estimator (Wooldridge, 2010, sec.14.2). The results are presented in Table 3. A Wald test on the null hypothesis of no correlation between ε and u has a χ^2 statistics of 1.340 and a p-value of 0.247, meaning that the outcome and treatment equations are statistically independent. In the treatment equation, the estimated coefficient for *PART* is statistically significant (p <

0.000) but that for *CA* is not (p = 0.201). It is unlikely that the statistical insignificance is due to multi-collinearity because the pairwise correlation coefficient between *CA* and *PART* is only 0.313. This means students who participate more actively in class are more likely to attend the experiment session, but a student's overall performance during the semester does not affect experiment participation. Turning to the outcome equation, we can see that the coefficients for both *CA* and *EXP* are statistically significant. As expected, a student's overall performance during the semester has a positive influence on the score of the oligopoly question. This implies that students who are more capable and/or with better learning attitude perform better in the oligopoly question. More importantly, experiment participation has a discernible positive effect on students' performance in the oligopoly question. On average, students who participated in the experiment scored 5.417 points higher than the other group in this 20-point question. This serves as a strong support to our hypothesis that classroom experiments conducted prior to relevant lectures can also help improve student learning outcomes.

Table 3. Endogenous treatment-effects regression results

	Estimated Coefficient	**Standard Error**	**p-value**
Outcome equation			
β_0	-1.097	3.024	0.717
β_1	0.276	0.133	0.038
β_2	5.417	2.187	0.013
Treatment equation			
γ_0	-6.020	1.870	0.000
γ_1	0.735	0.144	0.000
γ_2	0.069	0.054	0.201

Discussions and Conclusions

The goal of this study is to examine whether classroom experiments can improve student learning outcomes when the experiment is conducted before the relevant concepts are covered. We found that the group of students who voluntarily participated in an oligopoly experiment session performed noticeably better than the control group in all assessment tasks throughout the semester, but there is a much more pronounced difference between the two groups in their performance in a final exam question on oligopoly (65% difference) relative to that of the other assessments (23-30% difference). This potentially implies that experiment participation has a positive influence on students' performance in the exam question related to the classroom experiment. Our endogenous treatment effects regression results further reveal that experiment participation raised a student's score by 5.417 points on average in a 20-point question that was related to the experiment. Findings from the end-of-semester student evaluation questionnaires also indicate that students have gained valuable learning experience and knowledge in the topic concerned through the experiments. Their interest in the subject contents were stimulated and their understanding on how competitors interact in various market structures were enhanced. As discussed in the literature review section above, experiential learning is about the transformation of experience to knowledge. Our experiment served the role of providing students with a relevant experience in the context of the theories to be taught. It also helped students grasp the key components of the theories. The lecture teaching then guided the students through a reflection and thinking process to help them create knowledge. The effectiveness of this approach is demonstrated in the student learning outcomes.

Our results supplement existing findings in the literature by showing that experiments conducted before a relevant theory is taught can also improve student learning outcomes. Rather than helping students retain knowledge by allowing them to apply the theories they learned, our experimental design put students in the context of which a theory addresses. Our approach can provide students with prior knowledge and experience that is important for the understanding of a theory and improve students' motivation in learning the theory. Although our study focuses on the use of classroom experiments, the practical implication of our results is more far-reaching. In order to help associate students with the relevant subject matters to improve learning, lecturers may explore other effective and appropriate means that can be used to provide students with prior knowledge and experience. These means are course or topic-specific, and they may include case study, role play, gamification, etc., just to name a few examples. It should also be noted that the adoption of our approach is not limited to the economics and business disciplines. Given the educational value of first-hand prior knowledge, our approach may as well be suitable for other academic disciplines (e.g. humanities, social sciences, applied sciences, etc.) with a focus on real-world applicability.

Of course, our current research is not without limitations. Firstly, the sample size of this study is not big (around 60 students). This may have limited the capability of the endogenous treatment-effect model in correcting for the potential bias in our sample selection. Secondly, it will be more ideal if a comparison can be made between a group doing experiments before, and another group after relevant theories are taught. However, this calls for a very different experimental design and is out of the scope of this research.

To our knowledge, this study is the first that documents the efficacy of the use of classroom experiments in an Asian university. We encourage more research in this area with a broader geographical or demographical coverage, so that economic education researchers can better understand the application of experiential learning in different cultural settings. Further research in this area can also try to randomize the assignment of students into the experiment and control groups. This may minimize the influence of self-selection as encountered in this study.

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Corresponding author: Raymond Li
Contact email: ray.li@polyu.edu.hk

Learner-Generated Digital Media (LGDM) as an Assessment Tool in Tertiary Science Education: A Review of Literature

Jorge Reyna
University of Technology, Sydney, Australia

Peter Meier
University of Technology, Sydney, Australia

Abstract

Learner-Generated Digital Media (LGDM) in tertiary science education focuses on research skills, inquiry, active learning, teamwork, and collaboration. LGDM across disciplines is under-theorised, under-researched, and only in its early development. This paper evaluates the research in the field of LGDM in tertiary science education. The literature review had four stages – identification, screening, filtering, and selection of relevant scholarly research. Results showed that research in the field of LGDM assignments had been done without a systematic approach to designing, implementing, and evaluating the assessment task. Most studies neglected student digital media training and are characterised by a lack of compelling marking rubrics or strategies to ensure efficient groupwork. Studies also lack rigorous methodologies for data capture to evaluate the intervention and they use small sample size cohorts and different digital media types that require different sets of production skills. With the empirical data available, validation of the benefits of LGDM assignments in science education is not possible, and studies have limited scalability. These gaps in the literature create a need to develop theoretical models for the design, implementation, and evaluation of LGDM in the classroom. This paper discusses future research needs in this field and the implications for assessment design.

Keywords: learner-generated digital media, digital media literacies, science education, student-created content, authentic assessments

Learner-Generated Digital Media (LGDM) can be defined as digital artefacts developed by students to showcase their learning (Reyna, Hanham, & Meier, 2018). To date, there is no consensus in regards to naming and LGDM can be called, for example, student-generated digital media, student-created content, user-generated content, multimedia projects, and students as co-creators of content. LGDM include different media types such as podcast, digital story, screencast, animation and video, which adds an extra layer of complexity to a highly atomised field of research. For instance, to conduct a literature review in the field, it was necessary to use a multi-search strategy. The rationale is to use digital media as a vehicle for learning the subject content and developing graduate attributes such as technological skills (Buckingham, 2007), time management (Frawley, Dyson, Tyler, & Wakefield, 2015; Pearce & Vanderlelie, 2016), teamwork and collaboration (Coulson & Frawley, 2017), conflict resolution (Reyna, Horgan, Ramp, & Meier, 2017), and for fostering student engagement and creativity (Coulson & Frawley, 2017; Hoban, Nielsen, & Shepherd, 2015; Pearce, 2014). Research conducted in the last decade in the field of education has described the use of digital media assignments with the main focus on reflective practices for pre-service teachers (Kearney, 2013; Rich & Hannafin, 2009). In contrast, in science disciplines, it can be considered a novel approach focused on the development of research skills, inquiry, and active learning (Hoban et al., 2015). Documented examples include use in biology (Pirhonen & Rasi, 2016), health sciences (Pearce & Vanderlelie, 2016), and pharmacology (Henriksen, Henriksen, & Thurston, 2016; Nielsen, Hoban, & Hyland, 2017; Reyna, Meier, Geronimo, & Rodgers, 2016). Other disciplines where it has been used include computer programming (Powell & Robson, 2014; Vasilchenko et al., 2017), geology (Reyna et al., 2017), mathematics (Calder, 2012; McLoughlin & Loch, 2012), and engineering (Anuradha & Rengaraj, 2017).

LGDM across disciplines in higher education is considered under-researched (Hakkarainen, 2009), under-theorised (Potter & McDougall, 2017), and lacking in practical frameworks to implement it outside the Education discipline (Reyna et al., 2018). There is a lack of rigorous studies evaluating its effectiveness in different disciplines (Duffy & Jonassen, 2013; Hoban et al., 2015; Kearney & Schuck, 2005). This literature review will cover the different approaches trialled to embed LGDM into tertiary science education, and it will critically evaluate the assumptions, theoretical models (if any), and the methodology for evaluating the intervention and its outcomes. Media range from audio podcast (Bartle, 2015), which is considered an elementary form of digital media, to digital story (Rieger et al., 2018), screencast (Yang & Lau, 2018), animation (Wishart, 2017), and video (Hoban et al., 2015; Wishart, 2017). This literature review will also identify research gaps that have an impact on the implementation of digital media assignments in science curricula.

Literature review

Methodology

Research in the field of LGDM is segmented, due to the different names used to describe the intervention such as: (1) digital media for learning (DML); (2) learner-generated content (LGC); (3) student-generated content (SGC); (4) student-generated multimedia (SGM); and (5) learner-generated digital media (LGDM). An additional layer of complexity is the different digital media types, for example, podcast, digital story, screencast, animations, digital video, and so on. This literature research excluded blogs and wikis because, although they are forms of digital media, they do not promote multimodal representation of content like the other digital media types. These types of digital media do not need a storyboard for their production. New forms of digital media such as 360-degree video, Virtual Reality (VR), Augmented Reality (AR), and games also fell outside the scope of the review. A multi-research strategy captured available research in the field of LGDM. The literature review followed a protocol of identification, screening, filtering, and selection, the crucial steps for information-gathering (Figure 1).

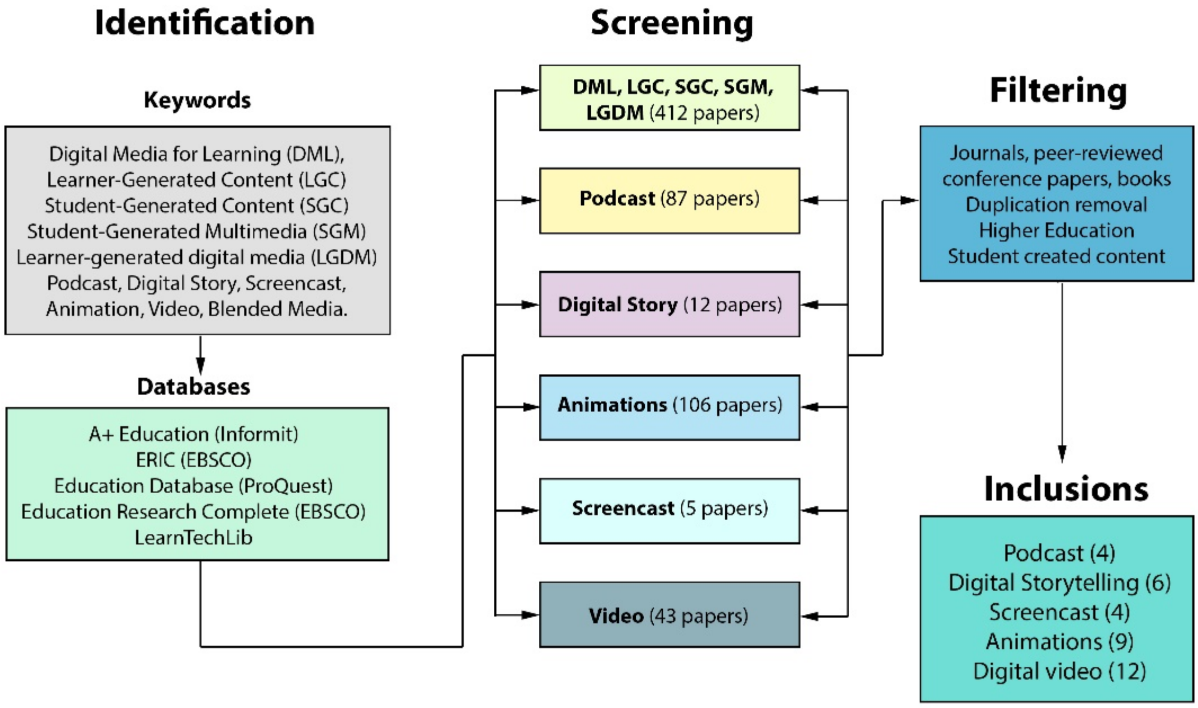

Figure 1. Literature review workflow on LGDM in science education

The keywords presented were used in the process of data gathering across reputable educational databases such as A+ (Informit), ERIC (EBSCO), Education Database (ProQuest), Education Research Complete (EBSCO), and LearnTechLib (AACE). The screening provided all papers that came up with the search. The filtering of papers left only peer-reviewed journals, conference papers, books, and student-created content. Suitable papers were downloaded and imported on EndNote X8, and duplicate papers were removed. Generic keywords such as DML, LGC, SGC, and LGDM in conjunction with ‘science education’ generated the highest number of results (n=412 papers). In most of the cases, the keywords found papers on using digital media to deliver subject content, for example, DML (n=322 papers), LGC (n=52 papers), SGC (n=36 papers), and LGDM (n=2 papers). In the case of podcast (n=87 papers), only four were on science students creating podcasts. Digital story (n=12 papers) was reduced to six papers, while screencast (n=5) was reduced to four papers. Digital video (n=43 papers) was reduced to eleven papers, and blended media (n=2) to one paper. Blended media papers were added to digital video as in essence; this is a video in the digital media industry. Animation (n=106 papers) was reduced to nine papers (Figure 1). The following sections present research on learner-generated podcast, digital story, screencast, animation, and video.

Learner-generated podcasts

A podcast is an audio file, usually recorded and compressed for online delivery (MP3 format), which can be delivered via web platform and downloaded directly to mobile devices for users to listen to (Geoghegan & Klass, 2008; Reyna et al., 2018). Educators have previously identified the benefits for students of the learner-generated podcast. Students can learn subject content by researching topics and preparing storyboards before recording audio podcasts (Hobbs, 2017). This task helps them to gain a deep understanding of the topic by narrating the content of the podcast (Digiovanni, Schwartz, & Greer, 2009). In the process of designing a podcast, students also develop new skills such as critical thinking (Frydenberg, 2006), teamwork, and collaboration (Lazzari, 2009; McGarr, 2009). It also improves technical skills, gets students motivated (Cane & Cashmore, 2008), encourages the development of reflective learning skills (Forbes, 2015; Lazzari, 2009), transforms the learner from a passive consumer of information into a producer, and enhances student creativity (Struck et al., 2011).

In science education, the available research on podcasting is limited and difficult to compare because of inconsistent approaches to evaluation. Furthermore, it has methodological problems, for example, some studies collected data equal to or less than a semester, used comparatively small undergraduate cohorts of less than 400 (first-year students), or used a qualitative approach via surveys and individual interviews (Fernandez et al., 2015). A qualitative study implemented learner-generated podcasts for a first-year chemistry class (n=350-400), with students allocated to groups of three. The study evaluated students' perceptions, task completion, motivation, and engagement and concluded that the learner-generated podcast led to deep learning of the subject content (Bartle, Longnecker, & Pegrum, 2011). The study used two Likert scale questions: (1) *The podcast activity helped me to get a better understanding of chemistry*; and (2) *The podcast activity was an enjoyable activity*. Two open-ended questions related to the advantages and disadvantages of podcasts for learning were also asked, and analysed using thematic analysis. The survey response rate was 35%. Limitations of the study included insufficient survey items to measure what was claimed (student perceptions, task completion, motivation, and engagement). A continuation of the study with a first-year chemistry class (n=352) (Pegrum et al., 2015) used a quantitative approach and supported the previous study. This study found a significant improvement in marks attained by students who engaged in podcast creation for learning when compared to a previous year cohort. The main limitation of this study was that comparison data was from the previous year when podcasting was not used. Neither study used a theoretical model to design the podcast assessment task, nor was media training offered to students.

In one case, a geography subject used a three-step model that included pre-production, production, and post-production (Kemp, Kotter, Mellor, & Oosthoek, 2009). Pre-production included brainstorming, logical structuring of the topic, and storyboarding. The production stage covered special effects like music and sound, designing the introduction, and recording, editing, and mixing the podcast. The post-production stage required producing a written summary or outline of the podcast and submitting the audio file to iTunes. This model is valuable but did not incorporate relevant aspects of podcast content discussed previously, such as the type of content, length, style, purpose, or the pace and intonation. The model is probably the most complete so far, but it does not have the educator and student role embedded in it. For example, how will this model inform the educator about designing a learner-generated podcast task? How will it inform the student about the assessment task? A continuation of the study a few years later concluded that the task enhanced student learning, competence with technology, creativity, and science communication skills (Kemp, Mellor, Kotter, & Oosthoek, 2012). The evaluation had a qualitative approach using informal discussion with students and the teaching team, and a questionnaire comprising closed and open-ended items. The study used data from 2008 (n=40) and 2010 (n=61) and noted low response rates to the questionnaire. This study used a theoretical model (Kemp et al., 2009) that informed the design of the task and also the creation of a marking rubric. Limitations included the methodology for gathering the data and the small size of the cohorts. Another qualitative study in postgraduate engineering students (in a mathematics subject) adopted an 'action research' approach (planning, action, observation, and reflection) to gauge students' views on learner-generated podcasting. Students appreciated the intervention but found podcast creation to be time-consuming and difficult (Adams & Blair, 2014).

In learner-generated podcast in science education, there is no comprehensive model for its implementation in the classroom which considers content and technical aspects and highlights educator and student roles. Studies are limited because it is a new approach. Most of the existing studies used a qualitative approach to data-gathering and analysis and did not use a framework to design the task. Studies are difficult to compare as they were undertaken in different disciplines and different settings. Most studies did not provide student training for the task. The research on podcasting and student learning in tertiary science education is thus inconclusive.

Learner-generated digital stories

Digital storytelling involves making a 3-5 minute video composed of images and voice-over (Martinelli & Zinicola, 2009). It is an arts-based research method that has the potential to explain complex narratives (Rieger et al., 2018) and to engage the audience and trigger their emotions by creating an unforgettable experience (Reyna et al., 2017). This digital media type can be created using PowerPoint, Movie Maker, iMovie, or similar software (Frazel, 2010; Hussain & Shiratuddin, 2016). Outside science disciplines, digital storytelling has been used to close the gap between facts and understanding, prompt reflection on experiences, embody agency, and assist meaning construction and formation of identity (Chan, Churchill, & Chiu, 2017; Martinelli & Zinicola, 2009; Niemi & Multisilta, 2016; Özüdoğru & Cakir, 2017; Shelton, Warren, & Archambault, 2016). In public health campaigns, digital stories are used to effectively convey complex messages to the general public (Rieger et al., 2018), but digital storytelling in higher education is still under-studied and under-used (Dewi, Savitri, Taufiq, & Khusniati, 2018).

In science disciplines, digital stories have been used to deploy content in blended learning (Molnar, 2018), but rarely used for students to engage in the creation of content. Learner-generated digital stories have the potential to help students in the classroom to learn by translating complex scientific concepts into personal narration. For example, in the process of drafting a storyboard, students have the opportunity to transform information into a simple visual representation (Martinelli & Zinicola, 2009). Regrettably, use of digital stories in science education as an assessment task is infrequent. The reason behind this is that the scientific community does not see digital stories as a rigorous methodology for presenting information (Martinelli & Zinicola, 2009; Schrum, Dalbec, Boyce, & Collini, 2017).

In undergraduate biology (Year 1) and environmental science (Year 2), the digital story has been used in assessment tasks (Ross, 2015). However, the methodology for this research was not straightforward and did not include the analysis of data. Students reported the task of producing the assignment to be time-consuming (+30 hrs). The study used a marking rubric that assessed content, creativity, and language. 'Creativity' seems mismatched with this rubric, which was more concerned with the technical aspects of the task. Outside creative disciplines, how can creativity be measured objectively? The research did not include qualitative or quantitative data. As a result, the study is inconclusive.

A study has reported on the use of digital story in postgraduate science education to improve student communication skills. The framework used was based on the process developed by the

Story Center in 2014 and included seven steps: (1) students see examples; (2) concept check; (3) brainstorming; (4) script and critique; (5) storyboard; (6) production; and (7) exhibition and evaluation. The methodology for the study was unclear, and it used three examples of digital stories developed by students, surveys, and interviews, but the data was not included in the paper. The study concluded that digital stories provided an opportunity for ESL science students to explore digital media and multimodal communication, learn about the subject topic, and improve communication skills (Purser, 2015). Another study with undergraduate (n=8) and postgraduate students (n=4) used the framework described and asked six open-ended questions to evaluate the intervention. Students said that they enjoyed the freedom to create material using their ideas and skills and reported minor technical issues (Martinelli & Zinicola, 2009).

The uses of learner-generated digital stories in science education are in its early stages. Although theoretical frameworks for storytelling have been applied, a methodology for gauging student learning or perception is not comprehensively explained in the literature. The research in this field seems to be more anecdotal than rigorous.

Learner-generated screencasts

Screencasts are recordings of the computer screen, with or without narration, using software such as Camtasia Studio, CamStudio, Macintosh QuickTime, or online applications like Screencast-o-Matic. They have become popular in higher education to develop training materials for students in flipped classroom interventions (Carney, Ormes, & Swanson, 2015; Talbert, 2014). Student-generated screencasts are only a recently emerging trend in higher education, and the literature is scarce. A literature search on student-generated screencasts identified only four papers in science education, exclusively in computer programming subjects. In one study, students were asked to create screencasts as a form of note-taking in tutorials. The trial included two groups, the group of students creating screencasts and the others who did not. The research presented data from four semesters (n=225) and reported only on test scores. Findings suggested that students who created screencasts as note-taking during tutorials achieved better scores than students who used traditional note-taking (Powell, 2015). The limitations of this study included the lack of survey data and interviews and the possibility that students shared their screencasts with their peers.

A second study reported the use of learner-generated screencasts as tests of complement code writing. Previously, students had been asked to provide screenshots for the task (Woods, 2015). This paper's research methodology is unclear, and it is not known how many students participated in the trial. The author concluded that the screencasts generated by the students helped the instructor to evaluate the assessment task. The intervention was teacher-centred rather than student-centred. The author also mentioned that the screencasts helped students to reflect on code writing. A similar approach was reported as a useful teaching approach in geometry, where students used screencasts for self- and peer-review (Shafer, 2010).

It is questionable whether creating a screencast that may, for example, not require a script can be considered learner-generated content. In contrast, if the task is to create a training video on how to use software or an application, students will need to be familiarised with the tool and learn a storyboard approach. They will also need working knowledge about editing the screencast and about digital media principles like colour schemes and typography, as they are likely to use on-screen text and prompts.

Studies of learner-generated screencasts in tertiary science education are currently rare in the literature, and future studies should consider the pedagogy behind the task. For instance, students learning about an application or software by preparing screencast training material would be an ideal use of screencast. That task would require a storyboard to help students to learn the software. There is a need to undertake studies on learner-generated screencasts that use defined methodologies and large samples to test their effectiveness for student learning.

Learner-generated animations

Animation is a sequence of frames put together to create a sense of motion. Producing animations was a time-consuming task until a decade ago. Designers could spend weeks creating an animated story. The affordability of technology helped to overcome this problem. For example, services such as Pow-toon (Graham, 2015) and GoAnimate (Stratton, Julien, & Schaffer, 2014) allow students to create animations in a short timeframe. This type of animation is called whiteboard animation, and it has been highlighted to communicate concepts online (Türkay, 2016). Online companies are using this approach to showcase their products on social media. In the past, animations were created using Flash Professional and required knowledge of ActionScript coding (Moock & Epstein, 2001). Educators of pre-service teachers coined the term 'slowmation' (slow animation) to refer to a type of student-created animation (Hoban, 2007; Hoban et al., 2015; Jablonski, Hoban, Ransom, & Ward, 2015). New names for existing categories of digital media will only create more atomisation of the LGDM literature and should preferably be avoided.

Constructionist theory, instructional design frameworks, and semiotic theory have all been used to explain learning with animations. For instance, when students prepare an animation to explain a science concept, they clarify, check, and refine their understanding (Hoban, Nielsen, & Carceller, 2010). Although there is no existing framework for implementing learner-generated animations in the classroom, the literature does discuss possible features of such a model, like purpose, timing, orientation, materials, and technology (Hoban & Nielsen, 2013).

With pre-service science teachers, case study design and discourse analysis (n=3) have been used to understand learning through creating a science animation. Research with pre-service teachers found that the process of meaning-making involved in such exercises fostered learning and reinforced the scientific concepts being conveyed. Multimodal representation of content, such as writing, still images, and voice-over, helped them to learn (Hoban & Nielsen, 2013). This research is comprehensive but cannot be generalised to a large cohort of students outside the discipline of education due to its qualitative nature. A study where undergraduate pharmacology students created animations during a two-hour tutorial found that students were anxious (39%), apprehensive (27%), intimidated (26%), lacking time to complete the project (67%), and lacking technical skills (54%) (Pearce, 2014). However, the study reported that students agreed that they had developed problem-solving, critical thinking, oral communication, teamwork, and management skills from the exercise. This research did not use a theoretical model for assignment design, and students did not receive media training. The data presented was gathered from a qualitative survey alone.

There is a lack of extensive studies to reinforce previous findings on the impact of animation in science education. The current affordability and ease of production of whiteboard animations created entirely online opens the possibility of a large-scale study to gauge their effect on learning further.

Learner-generated video
Learner-generated digital video for tertiary science education is the most common form of LGDM represented in the literature. Advantages of student-created digital video in education include the affordability of experiential learning (Coulson & Frawley, 2017), development of graduate attributes (Frawley et al., 2015; Pearce & Vanderlelie, 2016), new ways to represent knowledge (Hobbs, 2017), student engagement (Graybill, 2016), group collaboration (Coulson & Frawley, 2017; Pearce, 2014), project management (Cox, Vasconcelos, & Holdridge, 2010), and the development of technical skills (Morel & Keahey, 2016). Empirical data to validate these advantages are not available in existing research. Studies in the field have a flavour of guesswork, small samples, a qualitative nature, and lack of theoretical models to guide implementation of the assessment task. Moreover, most studies did not provide student training in video production. These drawbacks make it challenging to compare studies.

In a third-year undergraduate course in physiotherapy (n=75), no framework was used to implement the LGDM assessment task, and no training in video production was delivered to students. The results reported were mixed (Coulson & Frawley, 2017). Students reported stress and anxiety from problems related to the time given to complete the assignment, the group work involved, and assignment design issues. The study used a qualitative survey alone to gauge student perceptions and evaluate the intervention. A study in a geography subject followed the same pattern and lacked a framework to implement the assignment. However, it used a six-phase approach for the assessment task: (1) topic selection; (2) thesis statement and information/image gathering; (3) first narrative draft; (4) storyboarding; (5) videography workshop; and (6) viewing of videos on YouTube. Evaluative data was collected from routine institutional student surveys at the end of the semester (Graybill, 2016). The study reported student satisfaction with the assessment task, but issues with groupwork contributions and a lack of technical skills for creating a video.

Another study conducted with postgraduate students in health information management (n=8), using a qualitative survey, claimed that the assessment task developed critical thinking by creating a video that reinforced learning (Morel & Keahey, 2016). The study also suggested the development of project planning, management, and collaboration skills. It highlighted the need for clear assignment instructions and expectations, student training support, and strategies to improve groupwork such as assigning roles and responsibilities. The limitations of the study were its small sample size and the qualitative nature of the data.

Research with fourth-year pharmacy students (n=92) and second-year health sciences students (n=83) across two different institutions, using a qualitative survey, reported that students enjoyed working in teams and the creative nature of the task. They also felt that they developed graduate attributes such as problem-solving, critical thinking, communication skills, and time management (Pearce & Vanderlelie, 2016). However, the study reported that students were anxious (59%) and apprehensive (87%) about the task. Students did not receive video training or any technical assistance, and the assessment task did not use a theoretical framework. Limitations of the study included students undertaking different assessment tasks and being evaluated at different times.

Other studies on learner-generated digital video in science education (biology and geography) have the same limitations described above. These studies have in common small sample sizes, qualitative surveys, and lack of student training in digital media production (Anderson, 2013; Fuller & France, 2016; Pirhonen & Rasi, 2016). They concluded that both students and educators required coaching in video production (Fuller & France, 2016) and that storyboards were essential to master subject content before moving to video production (Pirhonen & Rasi, 2016). As previously suggested in the field of educational technology, it is likely that there are more cases of LGDM implementation in science education that have not been formally evaluated and published (Liu, 2016).

Conclusion

Learner-Generated Digital Media in tertiary science education is currently in its embryonic stages. There is no practical model for implementing LGDM assignments in the classroom which can be applied regardless of the digital media type. The lack of a model means that LGDM as an assessment tool is under-theorised and the lack of coherent methodologies to evaluate the student learning experience means the field is under-researched. However, a deficit in educator knowledge of digital media production workflow and digital media principles adds an extra layer of complexity to using LGDM assignments. The lack of compelling marking rubrics and neglect of student training provides evidence for this claim. These gaps in knowledge could explain the current status of research in the field. Learner-generated digital content, regardless of the type, has been acknowledged to have various advantages for science learning.

There is a great need to develop a practical framework for the design, implementation, and evaluation of LGDM assignments in tertiary science education. Ideally, the framework would be applicable across disciplines and different digital media types such as podcast, animation, digital story, or video. Its purpose would be to guide educators in designing, implementing, and evaluating digital media assignments and to get students to understand the rationale of the assessment task. The framework should be student-centred and should consider digital media training, groupwork contributions, student feedback, reflection, and so on.

Looking at the gaps in the literature, it will be necessary to develop a second model to inform student digital media training which considers conceptual, functional, and audiovisual skills. Conceptual skills developed here are searching for information and producing a storyboard, essential steps for students to understand the content before moving to the digital media production stage. Learning functional skills will ensure that students are capable of using digital media applications and will reduce the anxiety and apprehension reported with LGDM assignments. The digital media principles that apply to the creation of compelling digital media will develop audiovisual skills. Currently, most research on LGDM assignments perpetuates the 'digital natives' myth which leads to neglect of student training in digital media. Lack of student training could be due to the limited working knowledge of educators outside the disciplines of visual design, multimedia, film, or digital media about digital media production workflow.

A third model could use a taxonomy of digital media types, based on the skills required to develop the different types of digital media. This framework would inform educators in designing the LGDM task, mark weighting, group size, and comprehensive marking rubrics. From the student perspective, this taxonomy would inform them about the skills and training they need to produce LGDM assignments and to succeed in the assessment task.

Finally, a model is needed to define the minimum audiovisual skills required to produce digital media, for example, the digital media principles for production of compelling digital media artefacts, such as layout design, colour theory, typography, use of images, and basic video techniques. The US literature has highlighted that problems are not related to technology ownership, but fluency in its use (Alexander, Adams Becker, & Cummins, 2016). On the other hand, research papers on LGDM there have reported that students successfully produced quality digital media presentations (Coulson & Frawley, 2017; Pearce & Vanderlelie, 2016). Without an understanding of digital media principles and a good marking rubric, how can we evaluate the quality of LGDM content objectively? Moreover, how can educators fairly mark LGDM assignments if students do not receive formal training in digital media principles? It is therefore essential for educators implementing LGDM assignments to have a sound understanding of digital media production and its principles. LGDM should not be used exclusively as a vehicle for learning content, but also for learning to communicate effectively using digital media. Effective communication in the digital space is a required attribute for 21st-century graduates.

With the creation of the models discussed, it will be possible to apply a systematic approach to designing LGDM assignments for science education. Finally, a methodology for evaluating learning with digital media creation will be required to fill the gap in the literature and validate current assumptions about the benefits of LGDM. This approach should include a validated survey to gauge student attitudes to technology for learning and career development, their understanding of the assignment, their knowledge construction, and open-ended questions. Methodological triangulation of surveys against group dynamics and student marks should provide a sharper picture of the effectiveness of LGDM assignments.

This paper has highlighted the potential of LGDM assignments for science education, but rigorous studies taking systematic approaches to assignment design, implementation, and evaluation are required to validate assumptions.

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Corresponding author: Jorge Reyna
Contact email: jorge.reyna@uts.edu.au

Towards a Cross-Cultural Conceptual Framework for Researching Social and Emotional Education

Edurne Scott Loinaz
HAHA Academy, London

Abstract

The central aim of this study was to investigate how different countries practice social and emotional education (SEE) using a comparative research design to create a cross-cultural conceptual framework. The study used a sequential quantitative-qualitative analysis with a comparative design that included 750 teachers. Cross-cultural differences were found in the research sample regarding teachers' self-perceived role in socialising emotion: specifically, the teachers' openness to emotional expression in the classroom, and what social and emotional aptitudes were more likely to be included as part of SEE provision. More variation was found in these variables internationally compared to intranationally. A conceptual framework using two dimensions was created in order to aid future cross-cultural research regarding SEE provision and the study of emotional rules in the teaching profession: the Ideal Affect (likelihood of suppressing rather than expressing emotion) and the Ideal Self (likelihood of developing skills for independence versus interdependence).

Keywords: social and emotional education, comparative education, emotional wellbeing, social and emotional learning, emotional intelligence

Social and emotional education (SEE) is the educational process that aims to develop social and emotional competencies, both intrapersonal (e.g., developing feelings of self-worth, self-discipline and managing stress), and interpersonal (e.g., safeguarding and promoting the wellbeing of others, negotiating and resolving conflict and appreciating diverse perspectives). Given past findings that culture influences the way adults socialise children's emotions (Friedlmeier, Corapci, & Cole, 2011), it is unfortunate how scant the research dedicated to cross-cultural differences in SEE provision currently is. The necessity for research in this area is made all the more obvious the more emotional wellbeing is researched: take, for instance, the longitudinal study by Layard, Clark, Cornaglia, Powdthavee, and Vernoit (2014) which found that a person's wellbeing as an adult is more dependent on their emotional health when they were a child compared to their academic attainment in school and their level of wealth as an adult. How schools develop social and emotional competencies and promote emotional wellbeing in children and young people is thus of great importance. This paper aims to fill the gap in the research literature by conducting the first multiple-country study regarding teachers' beliefs and practice of SEE in order to create a conceptual framework to compare SEE provision from culture to culture for future research. This will hopefully aid in the cross-cultural study of 'emotional rules' in the teaching profession, and how these impact other aspects of learning and school life (Zembylas & Schutz, 2009).

Literature review

The available literature regarding SEE includes the evaluation of social and emotional learning programmes in schools cross-culturally (Sklad, Diestra, De Ritter & Gravesteign, 2012; Wigelsworth et al., 2016); a comparison of educational policy relating to social and emotional skills (Domitrovich, Durlak, & Gullotta, 2015; OECD 2015; Emery, 2016); and a summary of relevant SEE policy and best practice in various countries (Fundacion Botin, 2008, 2011, 2013, 2015). This research, however, does not focus on teachers' opinions and beliefs regarding SEE, and tends to treat teachers as faceless variables in the testing of outcomes (i.e., whether students' social and emotional aptitudes improved after a SEE intervention using psychometric testing). Research that does exist involving teachers' opinions and practice of SEE have so far been done as single-country studies: in Greece (Triliva and Poulou, 2006; Poulou, 2017), in Australia (Djambazova-Popordanoska, 2016), and in Turkey (Esen-Aygun & Sahin-Taskin, 2017).

In order to research multiple countries for the present study, the variables of culture were explicitly defined as information (ideas, beliefs, values, skills, attitudes, and knowledge) acquired from other individuals via social transmission mechanisms (e.g. teaching, imitation) (Mesoudi, 2011). The most common method to compare different cultures in past research has been the use of cultural dimensions, and the first systematic review of studies of cultural difference was completed by Inkeles and Levinson (1969). They proposed three 'cultural issues' that commonly differentiated groups: relation to authority; self-concept and the definition of gender roles; and conflict resolution, which primarily relied on the expression versus inhibition of emotion. Inkeles and Levinson's work greatly influenced the Dutch comparative psychologist Geert Hofstede (1980) who used 100,000 standardised questionnaires given to IBM workers in over 53 countries to identify the variables that would predict the cultural differences in his dataset. Hofstede identified four cultural variables in total and scored each country's cumulative answers as a position from 0-100 on each dimension. Taras, Kirkman and Steel's (2010) '*A Three-Decade, Multilevel, Meta-Analytic Review of Hofstede's Cultural Value Dimensions*' found 598 studies that used Hofstede's framework representing over 200,000 participants and concluded that the dimensions remain theoretically relevant to the study of cultural differences.

Hofstede's 1986 paper, '*Cultural Differences in Teaching and Learning,*' was used in the present research to create a series of hypotheses using two specific dimensions - the Uncertainty Avoidance (UA) Index (the degree to which members of a society feel uncomfortable with uncertainty and ambiguity), and the Masculinity Index (MI) (the degree of differentiation of gender and the division of emotional roles). Hofstede used these dimensions to predict cultural differences in the teacher-student relationship - 'the device par excellence by which that culture itself is transferred from one generation to the next' (Hofstede, 1986, p. 302) - and these predictions helped form the hypotheses for cultural difference in SEE provision that were used in the present research (summarised in Table 1).

Table 1. Cultural differences in teacher/student relationships and predictions for social and emotional education provision.

Low UA	**SEE hypotheses**	**High UA**	**SEE hypotheses**
Students feel comfortable in unstructured learning situations.	SEE has vague objectives, and is not timetabled. Low training in SEE. Preference for implicit SEE skills and reliance on modelling. Low expression of emotion.	Students feel comfortable in structured learning situations.	SEE has precise objectives, and is timetabled. High training in SEE. Preference for explicit SEE skills and reliance on didactic teaching. High expression of emotion.
Low MI	**SEE hypotheses**	**High MI**	**SEE hypotheses**
System rewards students' social adaptation.	SEE is believed to be as important as academic subjects. Teachers feel responsible for socialising students.	System rewards students' academic performance.	SEE is believed to be less important than academic subjects. Teachers do not feel responsible for socialising students.
Minimum emotional and social role differentiation between the genders.	Similar replies to the importance of SEE from both male and female teachers.	Maximum emotional and social role differentiation between the genders.	Different replies to the importance of SEE between male and female teachers.
Interdependence ideal.	Interpersonal skills are prioritised (safeguarding and promoting the wellbeing of others; social skills, negotiating and resolving conflict; appreciating diverse perspectives).	Independence ideal.	Intrapersonal skills are prioritised (self-discipline; setting goals; developing feelings of self-worth; recognising triggers of anger; understanding, and labelling emotion; relaxation techniques).

Methodology

The study used a sequential quantitative-qualitative analysis with a comparative design, with 750 teachers in an initial quantitative phase participating in a questionnaire, and 22 teachers in the following qualitative phase participating in semi-structured interviews. The comparative design used a *contrast of contexts* method which works best when the cases that it juxtaposes are maximally different (Skocpol & Somers, 1980). Thus, the four case studies for this current research project were chosen from Hofstede's (1986) cultural groupings that were most likely to socialise emotion differently, as well as other variables to differentiate the cases (more specifically, whether the country had SEE policy, and whether the education system was centralised or decentralised). The case studies chosen were:

1. United Kingdom: a highly decentralised education system with varying levels of SEE provisions (High MI, Low UA)
2. Spain: a regionally-centralised education system with varying levels of SEE provisions due to region-specific initiatives (Low MI, High UA)
3. Sweden: a highly decentralised education system, with no SEE provision (Low MI, Low UA)
4. Greece: a highly centralised education system, with no government-funded SEE provision (High MI, High UA)

The questionnaire was also devised to compare both international variation, and intranational variation in ten Likert scale questions. Frequency distributions by item were examined for both significance value (p) and magnitude of Cohen's effect size (d). This was due to the methodological and theoretical significance of within-culture variation, discussed in more depth by Au (1999), who warned that average levels of conformity in each culture cannot reveal cross-cultural difference in variance, and what is needed is the standard deviations of measures between each of the case studies.

For the quantitative data collection, surveys were used to collect original data using the Opinio web-based survey software. In order to have as many teachers participate as possible, and to be able to have a random sample, virtually every school in each of the four countries was sent an invitation email to participate using the SwiftMailer software and University College London (UCL)'s simple mail transfer protocol (SMTP) email server. A copy of the questionnaire invitation was sent to every school or teacher email address collected from education department websites and publicly available 'freedom of information' documents. The self-selection bias is thus one of the biggest limitations of the study.

For the qualitative data collection, semi-structured interviews were conducted with 22 teachers who were a sub-sample of the original quantitative sample (and included every teacher who self-selected to take part in a 50-minute interview as part of the prior questionnaire). The demographics for both the participants in the quantitative and qualitative section of the research were similar: 73% female and 26% male; 52% held an undergraduate degree, 46% a postgraduate degree, and 2% a high school degree; 13% were preschool teachers, 52% primary teachers, and 35% secondary teachers; 11.7% were 20-30 years old, 22.3% 31-40 years old, 32.7% 41-50 years old, 30% 51-60 years old, and 3.2% 60+ years old. Questionnaire responses to open-ended questions and interview responses were analysed using Braun and Clarke's (2006) six-phase model of thematic analysis, as well as quantified to ascertain their frequency. Full information on the purposes of the research were provided to all participants in the initial email sent to teachers, plus an invitation to be included in the dissemination of the findings. All participants had the right to withdraw from the research at any time.

Findings

Ideal affect

From the hypotheses created from Hofstede's (1986) uncertainty avoidance index, it was predicted that the Swedish and UK teachers (who rated low on the uncertainty avoidance index) would model the suppression of emotion (the inhibition of affect) and favour the control and management of emotion in their classrooms. The curriculum would have vague objectives - if any at all - and SEE would be more likely to be infused into the curriculum as implicit skills learnt via modelling, rather than taught as a separate subject. Furthermore, most teachers would not receive specific SEE training. These predictions and the current study's findings for these two countries are summarised in Table 2.

Table 2: Results in cultural differences in teacher/student relationships and social and emotional education provision in Low Uncertainty Avoidance cultures.

Prediction	**Were the predictions confirmed by the findings?**	
	UK	**Sweden**
SEE has vague objectives, and is not timetabled.	No. Out of the four countries, the UK was the most likely to have SEE timetabled (61% of preschool and primary schools, and 56% of secondary schools). However, this was partly due to the Labour government's SEAL* framework which was discarded by the Coalition government in 2010.	Yes. SEE did have vague objectives and no SEE framework had been created nor implemented in Sweden. Only 26% of Swedish primary teachers and 34% of secondary teachers said they timetabled SEE.
Teachers model the suppression of emotion.	Yes. Only 63% of UK teachers in the sample agreed that teachers should be comfortable expressing their emotions in class - the lowest percentage in the sample.	Yes. Although 73% of Swedish teachers agreed that teachers should be comfortable expressing their emotions in class, only 51% of teachers agreed that negative-evaluating emotion should be displayed in the classroom.
Low training in SEE.	No. UK had the highest training in SEE out of the four case studies (40% of UK teachers said they had received training in SEE).	Partly. Although 38% of Swedish teachers said they had received training for SEE, Sweden had the highest drop in SEE training over the past two decades.
Preference for implicit SEE skills and reliance on modelling.	No. 38% of primary school teachers, and 34% of secondary school teachers said they taught SEE implicitly - the lowest percentage in the sample. Developing students' social and emotional aptitudes were more likely to be mentioned by UK teachers also.	Yes. Teachers were much more likely to teach SEE implicitly (67% in primary school, and 56% in secondary school). Swedish teachers discussed the quality of their interactions with their students and modelling more frequently, rather than developing and assessing students' social and emotional skills explicitly.

*The Social and Emotional Aspects of Learning' (SEAL) programme (Department for Education and Skills, 2005) was the Labour government's universal, whole-school social and emotional education programme created as an 'objective list model': a series of skills as defined by a steering group (42 competencies in total in five skill groups: self-awareness, self-regulation, motivation, empathy and social skills), that could be measured and assessed by teachers. By 2010 SEAL was operational in 90% of primary schools and 70% of secondary schools (Humphrey, 2012).

On the other hand, Spanish and Greek teachers who rated high on the uncertainty avoidance scale would allow for more emotion to be displayed in the classroom (the expression of affect) and prioritise how emotions should be communicated. The SEE provision in Greece and Spain would have explicit objectives, would be more likely to be timetabled in the school day and taught didactically as well as by modelling, and most teachers would receive training. These predictions and the corresponding findings are summarised in Table 3.

Table 3. Results in cultural differences in teacher/student relationships and social and emotional education provision in High Uncertainty Avoidance cultures.

Prediction	**Were the predictions confirmed by the findings?**	
	Spain	**Greece**
SEE has precise objectives, and is timetabled.	No. Spanish primary school teachers were more likely to teach SEE using relational approaches and modelling (66%) rather than timetabling SEE with precise objectives (29%). In comparison, 44% of Spanish secondary school teachers timetabled SEE showing a significant difference between SEE provision in primary and secondary school.	No. Greece does not currently have a SEE framework, and was the least likely to have the subject timetabled out of all the four case study countries: 32% of Greek primary school teachers and 20% of secondary school teachers in the sample timetabled SEE provision.
Teachers encourage the expression of emotion.	Yes. 83% of Spanish teachers in the sample agreed that teachers should be comfortable expressing their emotions in class - the highest in the sample. 72% of teachers also agreed that negative-evaluating emotion should be displayed in the classroom - again, the highest in the sample.	Partly. 67% of Greek teachers said they should feel comfortable expressing their emotions in class - the second lowest in the sample. However, Greek male teachers were found to be significantly more comfortable expressing their emotions in class, including negative emotion, compared to female Greek teachers ($p < 0.05$, $d = .44$ suggested a small to moderate practical significance).
High training in SEE.	Partly. The Spanish teachers were the least likely to have received SEE training (23%), however, Spain had the largest increase in new teachers training for SEE relative to the other countries.	Yes. 34% of teachers trained in SEE, with a large emphasis on teacher training for SEE in the university - a percentage that was relatively high compared to other countries.
Preference for explicit SEE skills and reliance on didactic teaching.	Partly. A higher percentage of Spanish teachers were found to teach SEE explicitly in secondary rather than in primary.	Yes. When SEE programmes were implemented, these were more likely to be taught explicitly focusing on developing and assessing students' social and emotional skills.

Ideal self

The second Hofstede dimension that was used in the present research was the Masculinity Index. For this dimension it is the UK and Greece that are rated high on the index, predicting that the Greek and UK teachers would emphasise skills that help students be independent, for example: self-discipline, setting goals and developing feelings of self-worth. Other hypotheses included that teachers of different genders would also hold different views in terms of their responsibility to socialise students, and that there would be a greater tendency for teachers to believe that the role of education is solely academic achievement and not the socialisation of pupils (which they would believe to be the responsibility of parents/guardians). The findings for these two countries are summarised in Table 4.

Table 4. Results in cultural differences in teacher/student relationships and social and emotional education provision in High Masculinity Index countries.

Prediction	**Were the predictions confirmed by the findings?**	
	UK	**Greece**
SEE emphasises intrapersonal skills more	Partly. 56% of UK teachers taught intrapersonal skills regularly (e.g., developing feelings of self-worth, self-discipline, managing stress) - the highest in the sample. However, UK teachers were just as likely to teach interpersonal skills (65%).	Partly. 45% of Greek teachers taught intrapersonal skills (which was relatively higher compared to Swedish responses), but 52% of Greek teachers in the sample said they were more likely to regularly teach interpersonal skills (e.g., safeguarding and promoting the wellbeing of others, negotiating and resolving conflict, appreciating diverse perspectives).
SEE believed to be less important than academic subjects.	Partly. This was a subject that hugely divided the UK participants with one group believing SEE was beyond their remit, and the other believing SEE was the keystone to learning.	Yes. SEE was largely defined by Greek teachers as a means to an end to improve academic attainment.
Maximum differentiation in gender responses regarding SEE.	No. UK had the least differentiation between male and female teachers in the present study.	Yes. Greece had a significant difference between male and female teachers in multiple responses compared to the other countries: male teachers felt more comfortable expressing emotion, believed they had better teacher-student relationships, and that they had better relationships to students' parents compared to their female colleagues.
Female teachers more likely to feel responsible for socialisation	No. Both male and female teachers believed themselves responsible for socialisation- no significant difference was found.	No. Both male and female teachers believed themselves responsible for socialisation - no significant difference was found.

In turn, Spain and Sweden which are rated low on the masculinity index by Hofstede, were hypothesised to be more likely to help students learn skills that let them live in harmony with others, such as: safeguarding and promoting the wellbeing of others, social skills, negotiating and resolving conflict and appreciating diverse perspectives (empathy). Both male and female teachers would feel responsible in socialising students, and think this responsibility to be as important as the academic achievement of their students. The predictions are summarised in Table 5.

Table 5. Results in cultural differences in teacher/student relationships and social and emotional education provision in Low Masculinity Index countries.

Prediction	**Were the predictions confirmed by the findings?**	
	Spain	**Sweden**
SEE emphasised intrapersonal skills more.	Yes. More interpersonal skills were regularly taught by Spanish teachers (63%) compared to intrapersonal skills (49%).	Yes. More intrapersonal skills were regularly taught by Swedish teachers (53%) compared to intrapersonal skills (41%).
SEE believed to be as important as academic subjects.	Yes. There was a large commitment to SEE and the importance of emotion to learning. Those teachers who believed school was simply about academic attainment made up a small minority of the sample.	Yes. Although SEE is treated as outside of the teacher's remit, it was definitely within the school's remit, and school counsellors are available to all students in Sweden.
Minimum differentiation in gender responses regarding SEE.	No. A significant difference was found in multiple answers. Female Spanish teachers were found to be more likely to believe that emotion is fundamental to learning, that children can be taught SEE skills, that they should be responsible for socialising students, and that their students were offered enough opportunities to verbalise their emotions.	No. Female teachers believed themselves more responsible for socialisation than male teachers (see below).
Both genders feel as responsible for socialising students.	No. Female teachers believed themselves more responsible to socialise students than male teachers in the sample ($p < 0.05$, $d = .29$ suggested a small practical significance).	No. Female teachers believed themselves more responsible for socialisation than male teachers in the sample ($p < 0.05$, $d = .48$ suggested a small to moderate practical significance).

Intraregional versus international comparisons

A common objection in the literature regarding the comparative field is that international comparisons tend not to take into account the differences within each country, what is referred to in the literature as the intranational differences (Au, 1999). To address this issue, Likert scales in the current study were also assessed at the regional level to analyse what intranational differences did exist. Two items were chosen for this exercise, one with the most cross-cultural differentiation: 'Not enough attention is devoted to social and emotional education in my school' representing a divergence in two groups (Greece and Spain versus Sweden and the UK), and one with the least cross-cultural differentiation: 'My students have consistent behaviour goals between home and school' representing the least divergence (where Greece, Sweden and the UK had similar responses compared to Spain). Four regions with the highest number of respondents were chosen for each of the case study countries: Attica, Macedonia, Peloponnese and Thessaloniki for Greece (n=83); Balearic islands, Canary islands, Castile Leon and Navarra for Spain (n=166); North Middle, South Sweden, Stockholm and West

Sweden for Sweden (n=75); and East Anglia, Midlands, Scotland and South East England for the United Kingdom (n=152).

When looking at the Likert scale with the most cross-cultural divergence ('Not enough attention is devoted to social and emotional education in my school'), only one statistically significant difference at $p < 0.05$ was found intranationally: this was in Spain between Navarra and the Canary Islands ($d = 0.45$, which suggested a moderate practical significance), which, fittingly, are regions found almost 2,500 kilometres away from each other. Whereas internationally the variance in effect sizes varied in effect from $d = 0.18$ to $d = 0.92$, intranationally the variance in effect sizes varied from $d = 0.007$ to $d = 0.47$. International differences were thus more statistically significant and of a larger practical significance than interregional differences within the same country for this Likert scale (see Table 6). As can be seen with each of the four regions in each country, Spain and Greece were far more likely to have higher means than Sweden and the UK, suggesting that teachers from the former countries were more likely to be dissatisfied with their school's SEE provision compared to Sweden and the UK- this corroborates the international differences of the entire sample.

Table 6. Average mean answer from four individual regions in each case study country 'Not enough attention is devoted to social and emotional education in my school'.

UK	**South East**	**Scotland**	**East Anglia**	**Midlands**
Mean	2.63	2.53	2.43	2.39
SD	1.2	1.2	1.4	1.3
Number	62	19	40	31
Scotland	0.08	-	-	-
East Anglia	0.15	0.08	-	-
Midlands	0.19	0.11	0.03	-
Greece	**Macedonia**	**Attica**	**Peloponnese**	**Thessaloniki**
Mean	3.3	3.11	3.06	2.94
SD	1.1	1.2	1.2	1.1
Number	23	27	16	17
Athens	0.17	-	-	-
Peloponnese	0.21	0.04	-	-
Thessaloniki	0.33	0.15	0.1	-
Spain	**Navarra**	**Balearic Isl.**	**Castile Leon**	**Canary Isl.**
Mean	3.43	3.27	2.96	2.95
SD	0.9	1	1.1	1.2
Number	37	60	25	44
Balearic islands	0.17	-	-	-
Castile Leon	0.47	0.29	-	-
Canary islands	0.45*	0.29	0.01	-
Sweden	**South**	**Stockholm**	**North middle**	**West**
Mean	2.88	2.79	2.5	2.46

SD	1.1	1.2	0.8	1
Number	17	29	16	13
Stockholm	0.08	-	-	-
North middle	0.4	0.28	-	-
West	0.4	0.3	0.04	-

Note: The means of responses are presented in descending order. Higher means represent agreement that not enough attention is devoted to social and emotional education in the teacher's school. The grid is organised to present all pairwise comparisons and indicates the magnitude of Cohen's effect size (d) where .2 is small, .5 is moderate and .8 is large. * Significant at the (p) < 0.05 level ** Significant at the (p) < 0.01 level *** Significant at the (p) < 0.001 level

The questionnaire item with the least divergence (at least between Spain compared to Greece, Sweden and the UK) was 'My students have consistent behaviour goals between home and school'. This item had no statistically significant differences intranationally, although the international variations were found to be very similar in terms of effect sizes, with the largest effect size internationally being d = 0.59, and intranationally being d = 0.51. The regional differences, nevertheless, mimicked the overall groupings of the international findings, with Spanish regions being differentiated from the regions in the three other countries; that is to say, Spanish teachers were more likely to agree in every region that their students had consistent behaviour goals between home and school, whereas teachers from UK, Greece and Sweden were more likely to disagree (see Table 7).

Table 7. Average mean answer from four individual regions in each case study country 'My students have consistent behaviour goals between home and school'.

UK	**East Anglia**	**South East**	**Midlands**	**Scotland**
Mean	3.2	3	2.9	2.8
SD	1.2	1.1	1.3	0.9
Number	39	50	33	19
South East	0.17	-	-	-
Midlands	0.24	0.08	-	-
Scotland	0.38	0.2	0.09	-
Greece	**Peloponnese**	**Thessaloniki**	**Attica**	**Macedonia**
Mean	3.1	3.1	3	2.7
SD	0.88	0.8	0.87	0.93
Number	15	16	26	19
Thessaloniki	0	-	-	-
Athens	0.11	0.11	-	-
Macedonia	0.44	0.45	0.33	-
Spain	**Balearic Isl.**	**Castile Leon**	**Canary Isl.**	**Navarra**
Mean	3.5	3.5	3.4	3.2
SD	0.89	0.85	0.97	0.91
Number	53	31	41	30

Castile Leon	0	-	-	-
Canary islands	0.11	0.11	-	-
Navarra	0.33	0.34	0.21	-
Sweden	**West**	**North middle**	**South**	**Stockholm**
Mean	3.1	3.1	2.9	2.6
SD	1.1	0.73	0.74	0.86
Number	12	14	15	29
North middle	0	-	-	-
South	0.21	0.27	-	-
Stockholm	0.51	0.62	0.37	-

Note: The means of responses are presented in descending order. Higher means represent agreement that teacher's students have consistent behaviour goals between home and school. The grid is organised to present all pairwise comparisons and indicates the magnitude of Cohen's effect size (d) where .2 is small, .5 is moderate and .8 is large. * Significant at the (p) < 0.05 level ** Significant at the (p) < 0.01 level *** Significant at the (p) < 0.001 level

Discussion

Uncertainty Avoidance Index

The only reliable prediction based on Hofstede's (1986) cultural dimensions across the four case studies regarding the Low Uncertainty index was the expression rather than inhibition of affect. This dimension originally described by Inkeles and Levinson (1969) was created to explain differences in conflict resolution by inhibiting or expressing emotion. Taras, Kirkman and Steel (2010) also found that the predictive power of culture was higher than that of other demographic variables regarding emotion (or the 'ideal affect' of any given culture), and the present research corroborates this finding. Whereas Hofstede's Uncertainty Avoidance dimension was able to correctly identify the differences in treatment of emotion in the classroom, it did not do so in the case of Greece on account of gender – Greek female teachers felt more inclined to inhibit emotion rather than express it. The UK education system was found to act more in line with high uncertainty avoidance countries like Spain and Greece (using specific objectives regarding SEE and emphasis on teacher training), contrary to Hofstede's predictions as well. One correct prediction was Sweden's SEE provision which was more in line with lower uncertainty avoidance countries with its vague objectives and reliance on implicit approaches.

As they relate to SEE provision, the findings highlight that the inhibition as well as expression of emotion are currently being socialised both implicitly via modelling and a focus on the teacher-student relationship (relational approach), as well as by explicitly developing and assessing students' social skills, especially self-regulation and the management of emotion (competence-based approach). Hofstede's dimensions were found to not predict cultural differences due to two reasons: (1) the socio-political context (for example, in the UK the Low Uncertainty cultural dimension seemed more likely to predict the SEE policy of more Conservative governments, rather than more Liberal policy, such as the SEAL framework); and (2) the age of the students the participants were teaching (dimensions were more likely to predict teacher-student relationships in secondary school rather that primary school which could imply that Hofstede's dimensions are more applicable to teacher-student relationships of older rather than younger students).

Masculinity Index

The Masculinity Index was partly found to be a reliable predictor for what skills were more likely to be taught in each culture: intrapersonal skills (e.g., developing feelings of self-worth, self-discipline, managing stress) versus interpersonal skills (e.g., safeguarding and promoting the wellbeing of others, negotiating and resolving conflict, appreciating diverse perspectives). This was especially true for the United Kingdom, although these results might just indicate that the emotional and social skills that were part of the questionnaire were more relevant to UK teachers than to teachers in the other case study countries - especially since the framework of skills used in the study was similar to the UK's SEAL framework. As for the cultural differences regarding gender, this highlights a fundamental flaw in Hofstede's Masculinity Index: the cultural dimensions depend on cultural differences remaining the same, and culture is treated as a relatively stable concept with 'centuries-old roots'. The inability of the dimensions to predict gender differentiation in three out of the four cases begs to differ. The changes in gender relations over the 30 years since Hofstede wrote his dimensions (and almost 50 years since Inkeles and Levinson's meta review) highlight how culture is not that stable a concept.

The Masculinity Index, however, was found to be able to predict the difference in 'self-concept'. Barrett and McIntosh (1982) identified this as the differences between Right and Left political ideology. The Left represents the self as one dependent on other people, and the schooling environment is portrayed as a locus of affection that improves students' social and emotional skills for these interdependent relationships. The Right represents the need for self-help, self-support, self-sufficiency and self-respect, and sees the family (and concomitantly, the school system) as a means of instilling authority and a code of behaviour. Another correct prediction was the similarities between Greece and the UK, both high on the masculinity index, where teachers were found to not be as confident about teaching social and emotional skills to students as they were more traditional subjects, and where teachers were more likely to be divided about the importance of academic attainment versus social and emotional education.

Intraregional versus international comparisons

The results show that in the case of teachers' opinions regarding SEE, the more intranational variation there is, the less international variation, and vice versa. In other words, cultural differences regarding the socialisation of emotion do exist, along with differences in SEE provision. This is an important finding for future comparative research. A limitation to this analysis was the size of the samples of the individual regions - especially in Sweden and Greece - and this intranational comparison would need to be recreated with a larger sample to assess the differences more thoroughly.

Recommendations

Despite the weaknesses in Hofstede's dimensions to predict cultural differences in SEE provision, it was still an incredibly helpful starting point to begin to research a topic that has received little attention in the past. As Feyerabend (1975) advised, 'Theories become clear and reasonable only after incoherent parts of them have been used for a long time. Such unreasonable, nonsensical, unmethodical foreplay thus turns out to be an unavoidable precondition of clarity and of empirical success' (p. 18). Precisely for this reason, more detailed variables of cultural differences in SEE need to be identified, and for this reason the current study recommends using an updated conceptual framework to study social and emotional education in the future (see Figure 1). This conceptual framework combines all of the correct predictions of Hofstede's dimensions in the current study: the dimension of ideal affect (whether the teacher is more likely to feel comfortable expressing emotion in the classroom or not), and ideal self (whether the teacher is more likely to focus on skills for interdependence or independence). However, this conceptual framework could not incorporate the incorrect predictions of Hofstede's dimensions – such as the cross-cultural difference in emotional expression according to teachers' gender – and other conceptual frameworks are needed to study these particular cross-cultural differences.

It is important for future cross-cultural SEE research to highlight the differences between SEE provision in cultures that are more likely to suppress emotion compared to those that do not, as well as research the outcomes of differing 'ideal affect' on mental wellbeing in general. That teachers in some cultures are more likely to suppress emotion in the classroom is an important finding considering that adults socialise children's emotions by modelling (and thus students are being taught to suppress their emotions). In this respect, it does not matter how extensive and timetabled social and emotional education is if the aim of the provision is to more easily suppress emotion; negative consequences to regularly suppressing emotion have been extensively studied, particularly to the teacher's mental health and the concomitant desensitisation to other people's emotions (Cameron & Payne, 2011; Taxer & Frenzel, 2015; Lee et al., 2016). Without discounting the effects of income inequality and socio-political factors on mental health (World Health Organisation, 2009), emotional wellbeing can be influenced by many other variables that have not received as much attention in the research literature, and it should be a subject of further study just how much culture and the socialisation of emotion in schools are factors in overall emotional wellbeing.

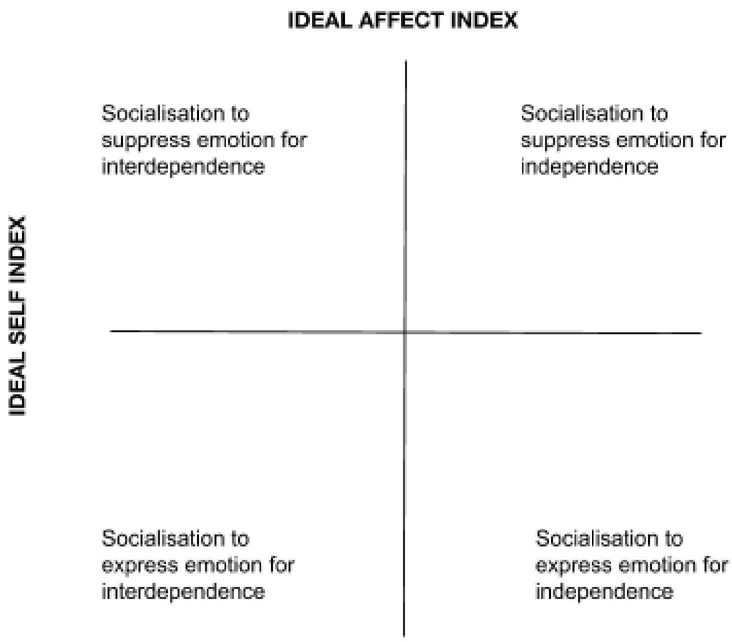

Figure 1. Plot graph of Ideal Affect (suppression versus expression of emotion) and Ideal Self (interdependence versus independence skills).

Conclusion

Cultural differences in teachers' opinions regarding social and emotional education were found to exist in the present study, along with differences in SEE provision from culture to culture. Hofstede's dimensions were able to predict cross-cultural differences in two aspects: the suppression versus expression of emotion, and the emphasis on intrapersonal skills versus interpersonal skills. These correct predictions have been used to create a conceptual framework for future research to identify how SEE seeks to develop ideal affect and the ideal self. However, the correct predictions of Hofstede's dimensions were vastly outnumbered by what they failed to take into account, including: differences in teachers' opinions according to gender, the differentiation of the teacher-student relationship between primary and secondary school, and what countries were more likely to teach SEE more implicitly (relational) rather than explicitly (competence-based approach). The author's hope is that the present study can serve to highlight the basic differences in SEE from culture to culture and serve as a foundation on which future research can be built.

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Corresponding author: Edurne Scott Loinaz
Contact email: edurne@haha.academy

The Effects of Using Representations in Elementary Mathematics: Meta-Analysis of Research

Andrzej Sokolowski
Lone Star College, Houston, Texas, USA

Abstract

The current study provides a meta-analysis of global research on using representations to support the learning of mathematics in Pre-K through Grade 5. A total of 13 primary studies encompassing 1,941 subjects was analyzed. The weighted mean effect size for the 13 studies was reported to be ES = 0.53 (SE = 0.05). A 95% confidence interval around the overall mean – $C_{lower} = 0.42$ and $C_{upper} = 0.63$ – proved its statistical significance and its relative precision. The calculated effect size signifies strong, robust support for the use of representations in Pre-K through Grade 5 mathematics classes and highlights the importance of providing students with opportunities to construct and explore transitioning between various forms of representations. Moderator analysis revealed differences among the effects due to a different type of representation, grade levels, and concepts taught. A synthesis of moderator effects allowed for a formulation of a general way of applying representations that produces maximum learning effects and that the teachers can adopt in their school practice. While the effect sizes provided a means of determining the most effective ways of applying representations, questions about how to develop students' transitioning from one representation to another remain unsolved. A further discussion of the impact of the study findings beyond the boundaries of elementary mathematics classrooms follows.

Keywords: meta-analysis, mathematical representations, internal and external representations, mathematics teaching and learning, elementary school

Introduction

It is well documented that reading and understanding a mathematical context requires embodying various abstract entities such as symbols, graphs, and tasks encoded symbolically in a language that students can comprehend. Given that elementary students are at the stage of developing their abstract thinking, designing effective teaching strategies that would allow such communication is not an easy task for mathematics educators and curriculum designers thus attempts are made to make the process more accessible for the learners. Research findings (e.g., Clark & Mayer, 2011) show that learning mathematical objects and the development of corresponding mental images are linked. On the other hand, imagination and the ability to construct, retrieve and explore internal representations form foundations for learning of mathematics (Lingefjärd & Ghosh, 2016). The ultimate question that was posited in this study was what representations are the most accessible to an elementary math student.

Researchers (e.g., Hoffler & Leutner, 2007) have determined that people learn more deeply from words supported by graphics than from words alone. This finding corresponds with the modern view on mathematical learning, which claims that utilizing multiple representations and making connections between graphical, symbolic, and verbal descriptions of mathematical relationships will empower and simultaneously help students develop a deeper understanding of mathematical relationships and concepts (National Council of Teachers of Mathematics [NCTM], 2000; Porzio, 1999). Following this notion, a general agreement exists that using different mathematical forms of representations and translating between these forms, are key skills in mathematics (e.g., Ainsworth, Bibby, & Wood, 2002). In order to respond effectively to learners' perception, further research is necessary. Nistal, Van Dooren, & Verschaffel (2012) noted that there was a need for research that would focus especially on the contextual factors that promote flexible representation choice for students in mathematics. It was hoped that this study would shed more light into this area.

Representations, especially their graphical forms, can also be perceived as learning experiences that are transmitted to the learner by pictorial media (Clark & Mayer, 2011). As such, they help the learner identify meaningful pieces of information and link the information with the learner's prior experiences. Although the constructs of using diverse forms of representations to enhance the development of mathematical concepts and problem-solving techniques have been widely researched (e.g., Jitendra, Star, Rodriguez, Lindell, & Someki, 2011; Weber-Russell & LeBlanc, 2004), a formal meta-analysis in this domain was not found using standard library search engines. Students' early experiences with the content of mathematics might have a profound impact on their further engagement and success in the subject. Therefore this study emerged to fill the gap and to provide a broader view of using representations to support the learning of mathematics in elementary school.

Theoretical Background

Representations and Constructivist Learning Theory

The effect of using representations is not new to the mathematics education community. However, it has recently attracted more attention by being supported by the constructivist learning theory that leads contemporary research in education (Cuoco, 2001). By treating mathematical concepts as objects, and thus embodying them with representations that can be observed and manipulated, a construction of mental pictures in the students' minds can be evoked (Dubinski, 1991). Such constructed mental pictures are stored in students' long-term memory and are available for retrieval. Research (Zazkis & Liljedahl, 2004) suggests that one of the ways to induce the process of converting concepts to objects is to create representations and act on them. Clark and Mayer (2011) suggested that knowledge acquisition is based on the following principles of learning: dual channel – people have separate channels for processing visual/pictorial material and auditory/verbal material; limited capacity – people can actively process only a few pieces of information in each channel at one time; and active processing – learning occurs when people engage in appropriate cognitive processing such as attending to relevant material and organizing the material into a coherent structure. Active learning appears as a method that supports the linkage of external representations with internal images.

Human cognitive architecture (Paas, Renkl, & Sweller, 2003), states that the most crucial structures affecting the rate of information processing are working memory and long-term memory. Human working memory has limited capacity as opposed to long-term memory, where capacity is unlimited (Kintch, 1998). For the information to be stored in a learner's long-term memory, it needs to be processed initially through its working stage. Being presented with complex information, the learner might feel overwhelmed, which might result in the information not being fully processed. This state will consequently block the information from reaching the learner's long-term memory and from being learned and accumulated. The primary goals of using representations are to reduce the contextual load by converting the information to a visual form and to transmit such information to the learner's visual channel. This process in return will reduce the need for high capacity of working memory. The virtue of using representations is rooted in their capacity to present the knowledge of conveyable graphical embodiments supported by verbal elaborations rather than vice versa. Such knowledge presentation creates appealing conditions for being longer retained and accessible for future usage.

Representations in Mathematics

Representations are broadly defined as passive entities. By learner's active engagement, they are transformed into active semiotic resources (Thomas, Yoon, & Dreyfuss, 2009) and can be stored in a learner's long-term memory. Knowledge externalized by graphics is easily retrievable for analysis and can be readily exhibited and communicated (Ozgun-Koca, 1998). Representations as a means by which individuals make sense of situations (Kaput & Roschelle, 1997) can be expressed in forms of combinations of written information on paper, physical objects, or a carefully constructed arrangement of thoughts. Schnotz (2002) emphasizes the distinction between descriptive (symbolic) and depictive (iconic) representations. While depictive representations are most useful to provide concrete information and are often effective as specific information, descriptive representations usually express abstract information. Duval (2006) claimed that using various representations in mathematics classes is a necessity because only multiple external representations allow learners to utilize the different advantages each representation offers. Falcade, Laborde, & Mariotti, (2007) claimed that the link between external representations and internal representations goes beyond pure analogy in their functioning and rests on the real tie that can be recognized between particular tools (external representations) and particular signs (internal representations).

Each representation of a mathematical object brings some aspects to the fore, simultaneously hiding other aspects of the object and thus affecting the way the object is seen (Laborde, 2007). Representations can also be used to explore aspects of a context that might otherwise not be apparent to a learner; they amplify properties of mathematical structures not easily imaginable (Monk, 2003). In the process of knowledge accumulation, representations are converted into internal images. Mediated by the level of entry into learners' memory systems, representations are categorized as external or internal. Both types of representations are interrelated in the sense that the meaning of an internal representation stored in a learner's long-term memory strongly depends on the learner's perception of its external counterpart.

External representations (see Figure 1) encompass physically embodied, observable configurations – such as pictures, concrete materials, tables, equations, diagrams, and drawings of one-, two-, or three-dimensional figures or various forms of schemata (Jitendra et al., 1998).

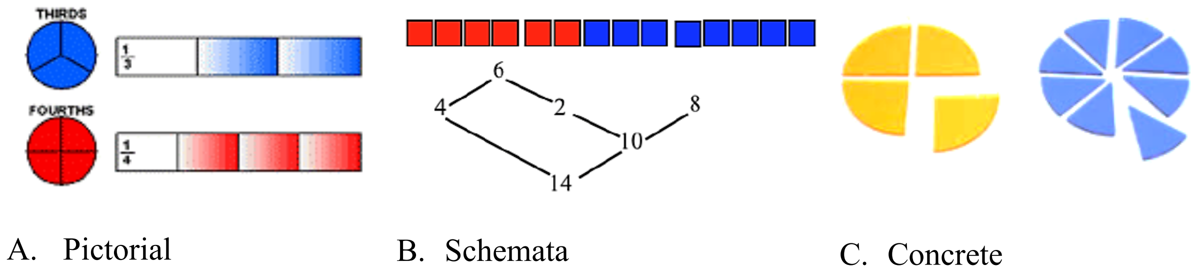

Figure 1. Examples of representations using in elementary school.
(Source: https://www.google.com)

All these embodiments can be provided in the form of drawings or can be digitalized by computer programs. They can also be generated by the instructor as he/she introduces the representations to the learners. External representations also encompass dynamic graphics, which are generated with the help of technology, for example, graphing calculators or computer-based simulations (Goldin & Shteingold, 2001). Ainsworth and Van Labeke (2004) categorize external representations as time-persistent representations, time-implicit representations, and static representations. In mathematical terms, time-persistent representations are embodied by algebraic functions, time- implicit by relations and static representations would encompass any drawings that students produce, not necessarily placing their products in a coordinate system.

Eisenberg and Dreyfus (1991) noted that students might end up with an incorrect solution if their algebraic skills are not strong; however, if they possess the skills to graphically solve the problem or support its solution process, the graphed representation might serve as a backup or a way of solution verification. Being exposed to mathematical representations, learners "acquire a set of tools that significantly expand their capacity to model and interpret physical, social, and mathematical phenomena" (NCTM, 2000, p. 4). In this regard, external representations can also serve as a means to overcome students' misconceptions in science classes (Thompson & Logue, 2006).

Internal representations encompass mental images corresponding to internal formulations of what human beings perceive through their senses and as such they cannot be directly observed. Internal representations are defined as the knowledge stored in a learner's long-term memory. Internal representations are formulated based on one's interaction with the environment (external representations) and are altered throughout a lifespan. In the process of learning, external representations prompt the emergence of internal representations. Being able to formulate concepts' internal representations through the process of understanding their external embodiments and retrieving the mental pictures plays an essential role in communicating messages in mathematics. Hiebert and Carpenter (1992) maintained that learners establish a strong relationship between created external and internal representations and that the strength of linking these representations determines students ‘understanding.

Furthermore, internal representations of the knowledge accumulated through experiencing visual representations produce stronger impulses in learners’ long-term memory. Enabling these experiences by engaging and intellectually stimulating learners through carefully designed learning environments supported by representations deems to be a significant factor in nurturing effective learning and developing students’ mathematical knowledge. Nitsch et al. (2015) found that that to understand the concept of function, that is central in mathematics curriculum, it important not only to know the different mathematical representations of functional dependency, but also the translations between these forms of representations. For students to develop a holistic understanding of the concept of mathematical functions, they have to be able to identify the connecting elements and to combine these representations.

Synthesis of Prior Research

As the constructivist theory strongly supports the use of representations in the learning process, several research studies have explored the effects of using representations on students’ math concept understanding. These results converge with contemporary theories of cognitive load and multimedia learning principles developed by Clark and Mayer (2011) and have practical implications for mathematical instructional designs. A meta-analysis of 35 independent experimental studies conducted by Haas (2005) shed light on using representations as a means of supporting teaching methods at the secondary school level. Haas concluded that math instruction, supported by multiple representations, manipulatives, and models, produced a high (ES = 0.75) effect size. Schemas, which are defined as generalized representations that link two or more concepts are frequently researched at the Pre-K through fifth-grade level. For example, Jitendra and colleagues (1998) found that having students of Grades 2-6 categorize problems and then having them solve the problems by using schemas produced a positive medium-size learning effect (ES = 0.45). The virtue of using representations embodied by schemas is that they are easily converted by learners into internal representations, and, as such, they can be stored in long-term memory and allow for treating diverse elements of information regarding larger, more general units (Kalyuga, 2006). According to Pape and Tchoshanov (2001), schematic representations also lead to enhanced student problem-solving performance.

Another group of researchers investigated whether representations should be provided to students or if the students should be the producers of representations (e.g., De Bock, Verschaffel, Janssens, Van Dooren, & Claes, 2003; Rosenshine, Meister, & Chapman, 1996). These scholars concluded that if representations are provided, their forms must be sufficiently informative and detailed to be transferrable by students into mathematical algorithms. They also emphasized that having students construct their representations benefits the learners the most. The importance of possessing the ability to transfer a given context (e.g., a story problem) into a representation was highlighted by Jonassen (2003), who claimed that successful problem solving requires the comprehension of relevant textual information along with the capacity to visualize that data and transfer it into a conceptual model. Following Riley, Greeno and Heller (1984), developing students’ abilities to identify the matching representation that helps with problem conceptual understanding should emerge as a priority of elementary mathematics teaching.

Representations are also used to support the introduction of new mathematical concepts. For example, several studies (Tzur, 1999) were conducted on the development of students' notations of fractional parts of areas, called *fair sharing*, which provided a meaningful representation of dividing a whole into parts that were then easily comprehended by elementary students. Hiebert (1988) noted that students' understanding of new ideas strongly depends on the degree to which the learners are engaged in investigating the relations between new representations and the representations whose understanding is already mastered. A study conducted by Ross and Willson (2012) not only supported the claim that mathematics students learn more effectively when instruction focuses on using representations but, moreover, proved that the most effective strategies for building representations are those rooted in constructivist learning theory. The range of using representations in Pre-K through fifth grade is wide, thus synthesizing the experimental research findings and identifying the most effective strategies manifests as a worthy undertaking.

Challenges of Inducing Representations in Pre-K through Grade 5

Investigating the effect of using representations has recently attracted more attention due to being supported by the constructivist learning theory that leads contemporary research in education (Cuoco, 2001). Such constructed mental pictures are stored in students' long-term memory and are available for retrieval. Research (Zazkis & Liljedahl, 2004) suggests that one of the ways to induce the process of converting concepts to objects is to create representations and act on them. Sfard (1991) concluded that the process of transferring abstract mathematical concepts into their mental images is challenging for both the learner and the instructor, who is to guide the learner through the transferring processes. What are the challenges faced by elementary school children as they attempt to embody mathematical structures into visual representations?

Equations and their conceptualization are frequently investigated in K-5 mathematics research. Swafford and Langrall (2000) noted that students generally can make use of various representations and can identify patterns between isolated variables, but they cannot find consistency among a larger set of variables or generalize the patterns and convert them into mathematical forms. Dreyfus (1991) suggested four learning phases with representations: using one representation; (using more than one representation; (making links between parallel representations; and integrating the representations. Representations at the elementary school level encompass general structures used in mathematics such as ratio, rate, percent or newly developed schemata for problem-solving, thus pinpointing and understanding how to uncover these principles acts as a catalyst for selecting correct representation. According to Swafford and Langrall (2000), the emphasis in the curriculum at the pre-algebra level should be on developing and linking multiple representations to generalize problem situations. They concluded that the lack of generalization skills is rooted in instruction focused on reaching only the initial stages of problem analysis and leaving the process of generalization for the students to formulate. A similar conclusion was reached by Deliyianni, Monoyiou, Elia, Georgiou, and Zannettou (2009), who observed that first-graders restricted themselves to providing unique solutions even though the questions required a general pattern formulation. Other researchers (e.g., Lesh & Harel, 2003) have shown that elementary school children bring potent intuitions and sense-making tools, yet how to mediate these intuitions with abstract math concepts to embody these concepts into representations is a challenge still facing the mathematics research community.

Research Methods

Meta-analysis, with its quantitative methods, was used to compute the research findings. Meta-analytic techniques provide tools to assess the learning effect size of treatments, considering a gathered pool of studies as a set of data collected within prescribed criteria. By allowing the measurement of the effect sizes according to the population of participants in primary studies, such undertaking allows for analyzing a larger number of studies that can vary by population sizes and also by the conduct (Gijbels, 2005). Furthermore, meta-analysis allows also for employing subgroup moderator analysis and extracting factors that contribute to the magnitude and direction of the mean effect size.

Research Problems

Based on the prior research, a hypothesis suggesting that using representations in mathematics helps students comprehend abstract mathematical concepts and enhances the skills of the concepts' applications emerged for this study. Understanding the degree to which representations help learners comprehend the different mathematics entities, compared to traditional methods of instruction, constituted the main objective of this study and guided the research questions:

1. What are the magnitude and direction of the learning effect sizes of using representations in Pre-K through fifth-grade mathematics when compared to traditional teaching methods?
2. What are the possible moderators that affect students' achievement and what classroom settings produce the most optimal learning effect sizes when representations are used?
3. What are the features of the most effective representations in mathematics suitable for Pre-K through Grade 5 levels?

It is hoped that the answers to these questions will advance the knowledge of using representations and assist math curriculum policymakers to design effective learning materials.

Data Collection Procedure

This meta-analysis sought to encompass 12 years of global research on using representations in Pre-K through fifth-grade mathematics, with student groups ranging in age from 3 to 12, in both public and private schools, with a minimum sample size of 15 participants. In the process of collecting the applicable research studies, ERIC (Ebsco), Educational Full Text (Wilson), Professional Development Collection, and ProQuest Educational Journals, as well as Science Direct, Google Scholar, and other resources available through a university library, were used to identify relevant studies published between January 1, 2000, and December 31, 2012. While extracting the relevant literature, the researchers used the following key terms: *graphical representations, mathematics education, primary, students, and experimental research*. In order to broaden the search, the terms *graphics, visualization*, and *problem-solving* were also used. Such defined criteria returned 131 papers, out of which 13 satisfied the conditions for meta-analysis (13 effect sizes). Several studies, although providing valuable findings, were rejected due their qualitative type (e.g., Castle & Needham, 2007) or due to their focus on comparing the effects of using representations that did not contain control groups (e.g., Coquin-Viennot & Moreau, 2003).

Coding Study Features

The main construct under investigation was the learning effect of using representations in Pre-K through fifth-grade mathematics classes. While some of the characteristics, for example, year of study conduct, locale, or type of research design, were extracted to support the study reliability, others, like grade level or intervention type, were extracted to seek possible moderators. Following are the descriptions of these features that were further aggregated to apply a subgroup moderator analysis.

Grade. This variable described the grade level of the group under investigation and referred to groups ranging from kindergarten to Grade 5.

Descriptive parameters. Descriptive parameters encompassed the locale where the studies were conducted, the date of publication, and the sample size representing the total number of subjects under investigation in experimental and control groups.

Publication bias. All studies included in this synthesis were peer-reviewed and published as journal articles; thus, no additional category for publication was created.

Group assignment. This categorization refers to the mode that was used to select and assign research participants to treatment and controlled groups. Two main groups were identified: (a) randomized, where the participants were randomly selected and assigned to the treatment and control group; and (b) quasi-experimental, where the participants were assigned by administrator selection. This categorization is aligned with Shadish, Cook and Campbell's (2002) definitions of group assignment.

Type of research designs used in the meta-analysis. Only pretest-posttest experimental studies with control groups were synthesized.

Intervention. The intervention (treatment approach) was classified into four categories reflecting the type of representations used in Pre-K through fifth-grade mathematics as defined by Swing, Stoiber, and Peterson (1988) and Xin and Jitendra (1999): pictorial (e.g., diagramming); concrete (e.g., manipulatives); mapping instruction (e.g., schemata based); and other (e.g., storytelling, keywords).

Output assessment. This variable described the assessment instrument and indicated whether the assessment was developed by the researcher or was standardized.

Data Analysis

The following analysis is organized deductively. It begins by describing the general study characteristics, moves to discuss the mean effect size, and concludes by presenting subgroup moderator computations. Such established sequence follows the order of the study research questions.

General Study Characteristics

The summary of the study characteristics extracted from the pool of experimental pretest-posttest studies is presented in Table 1.

Table 1. Tabularization of experimental pretest-posttest study features

Authors	Date	Locale	RD	SS	GL	IRT
Alibali, Phillips, & Fischer	2009	USA	QE	91	3rd & 4th	Pictorial
Van Oers	2010	Netherlands	QE	239	4th	Pictorial
Poland, Van Oers, &Terwel	2009	Netherlands	QE	54	2nd	Schemata based
Xin, Zhang, Park, Tom, Whipple, & Si	2011	USA	QE	27	4th	Schemata based
Booth & Siegler	2008	USA	R	52	1st	Pictorial
Csikos, Szitányi, &Kelemen	2012	Hungary	QE	244	3rd	Pictorial
Gamo, Sander, &Richard	2010	France	QE	261	4th & 5th	Schemata based
Terwel, Van Oers, Van Dijk, &Van den Eeden	2009	Netherlands	R	238	5th	Pictorial
Casey, Erkut,Ceder, & Young	2008	USA	QE	76	Pre-K	Other (storytelling)
Jitendra, Griffin, Haria, Leh, Adams, & Kaduvettoor	2007	USA	QE	88	3rd	Schemata based
Fuchs, Fuchs, Finelli, Courey, & Hamlett	2004	USA	R	436	3rd	Schemata based
Saxe, Taylor, McIntosh, & Gearhart	2005	USA	QE	84	4th & 5th	Pictorial
Fujimura	2001	Japan	R	51	4th	Concrete

Note. SS = sample size, GL = grade level, RD = research design, QE = quasi-experimental, R = randomized, IRT = intervention representation type.

The data revealed that there is substantial diversity in the representations used in elementary mathematics classes, ranging from schemas supporting problem-solving to storytelling supporting operations on fractions. The majority of the studies (nine, or 69%) were quasi-experimental, while four (31%) were randomized. Regarding grade, a dominating group of six studies was represented by fourth grade. Because problem-solving dominates the math learning objectives in K-12 math education, how representations help students improve their problem-solving techniques emerged as a possible moderator of the study. Considering the type of intervention, pictorial (six studies, or 46%) and schemata based (five studies, or 38%) dominated the pool.

The Mean Effect Size and its Significance

The quantitative inferential analysis in the form of a meta-analysis was performed on pretest-posttest experimental studies. The outcome variable, defined as the overall effect size of using representations in mathematics teaching was sought in this meta-analysis. Student achievement scores were further expressed as effect size computed using mean posttest scores of experimental and control groups and coupled standard deviation using Hedge's (1992) formula. For the meta-analytic methods to be applied, the responses for the experimental studies were standardized, and the accuracy of the effect sizes was then improved by applying Hedge's (1992) formula:

$$g = \frac{\bar{x}_1 - \bar{x}_2}{s*}$$

In this formula; $\bar{x}_1$ represents the posttest mean score of the treatment group, $\bar{x}_2$ represents the posttest mean score of the control group, and s^* represents pooled standard deviation. This process allowed the elimination of the sampling bias (Lipsey & Wilson, 2001).

The overall weighted mean effect size for the 13 primary studies (13 effect sizes) was reported to have a magnitude of 0.53 (SE = 0.05) and a positive direction. A 95% confidence interval around the overall mean – C_{lower} = 0.42 and C_{upper} = 0.63 – indicated a nonzero population effect and its relative precision (Hunter & Schmidt, 1990). According to Lipsey and Wilson (2001), an effect of 0.53 is of medium size. Herein, the overall effect's magnitude along with its positive direction indicated that the score of an average student in the experimental groups was 0.53 of a standard deviation above the score of an average student in the control groups. By incorporating the U_3 Effect Size Matrix (Cooper, 2010), the average pupil who was taught mathematics structures using representations scored higher on unit tests than 70% of students who were taught by traditional methods. Thus, it can be deduced that using representations in the teaching of mathematics, as a medium supporting instruction, has a profound impact on students' math concept understanding when compared to conventional methods of teaching. Therefore, contextualizing math ideas and letting students embed math operations in contexts meaningful to them has a positive effect on storing the ideas in their long-term memory. Table 2 provides a summary of the individual effect sizes of the meta-analyzed studies along with their confidence intervals and qualitative findings.

Table 2. Effect sizes of using representations in Pre-K through Grade 5

Study (First Author)	ES	SE	95% CI Lower	95% CI Upper	Research Findings	Source of Assessment
Alibali (2009)	0.92	0.22	0.19	1.05	The strategy of representing the process of equalizing equations improved problem representation techniques.	Researcher designed.
Van Oers (2010)	0.23	0.13	0.36	0.89	Children improved fraction understanding when they were allowed to construct own representations guided by the teacher.	Researcher designed.
Poland (2009)	1.22	0.29	0.04	1.23	Introducing dynamic schematizing improved understanding of the concept of the process during problem-solving.	Researcher-created schematizing test.
Xin (2011)	0.60	0.39	-0.19	1.44	Conceptual representations helped students learn the process of problem solving.	Used textbook items adopted by the districts; Cronbach 's alpha = 0.70.
Booth (2008)	0.20	0.28	0.05	1.19	Providing accurate visual representations of the magnitudes of addends and sums increased children's computational skills.	Wide Range Achievement Test–Expanded (WRAT–Expanded).
Csikos (2012)	0.62	0.13	0.36	0.88	Presenting word problems with different types of visualization (e.g., arrows) improved techniques of problem solving.	Test items adopted from National Core Curriculum; Cronbach's alpha = 0.83.
Gamo (2010)	0.61	0.14	0.34	0.91	Mapping data into graphical representations helped students with problems involving fractions.	Researcher designed.

Terwel (2009)	0.41	0.13	0.36	0.88	Having students learn to design representations helped them bring more model-based knowledge to the structure of mathematics problems.	Researcher developed criteria; Cronbach's alpha = 0.76.
Casey (2008)	2.00	0.31	0.38	2.63	Representing geometry concepts in a story context improved math knowledge retention.	Used Kaufman-Assessment Battery for Children (K-ABC; Kaufman & Kaufman, 1983).
Jitendra (2007)	1.36	0.22	-0.12	1.07	Addition and subtraction: used graphics to support multiple representations.	Used Pennsylvania System of School Assessment math test.
Fuchs (2004)	0.22	0.19	0.26	0.99	The applied schema for problem-solving improved students' algorithmic outcomes.	Researcher-developed.
Saxe (2005)	0.33	0.22	0.18	1.07	Percent: represented fractions with standard part-to-whole representations.	Researcher-developed.
Fujimura (2001)	0.71	0.29	0.05	1.20	Highlighting the idea of physical units in setting the proportions improved students' conceptual understanding.	Researcher developed; interrater agreement 97% (N = 76).

Note. ES = effect size, SE = standard error.

Calculated confidence intervals (CIs) for each effect size revealed that 11 of the effect sizes fell within 95% confidence intervals. The researcher used Statistical Package for the Social Sciences (SPSS) software to visualize the position of the effect sizes as well as the confidence intervals for each study around the computed overall mean of the pool of studies. Some means were revealed to be outside of the area of the funnel graph (see Figure 2).

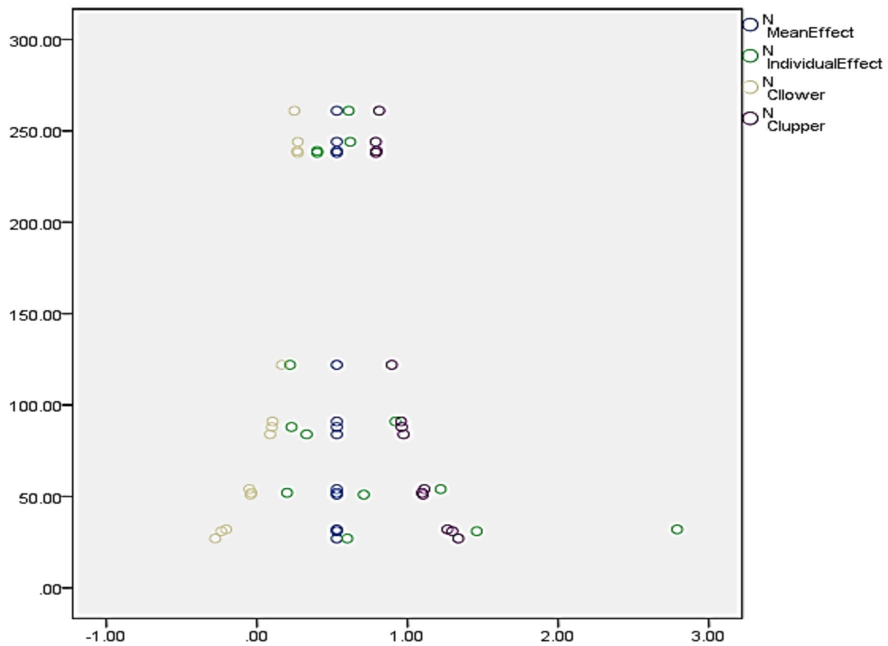

Figure 2. Funnel graph for the pretest-posttest experimental studies.

The individual effect sizes of some of the studies showed to be outside of the confidence intervals indicating a lack of homogeneity of distributions within the study pool. This was also depicted by the significant *p*-value ($p < 0.001$). As the purpose of a meta-analytic study is to compute effect size (Willson, 1983), the lack of homogeneity does not undermine the validity of the calculated mean effect; rather, it explicates the characteristics of the studies, indicating that some of them originated from different distributions.

The highest learning effect size (ES = 2.00) was generated in a study conducted with kindergarten pupils who were exploring the creation of verbal representations of geometry concepts (Casey, Erkut, Ceder, & Young, 2008). This study revealed that immersing math concepts in an environment that students can relate to their experiences and fantasies and letting students explore the links makes the math concepts tangible and results in them being easily stored in students' long-term memories. Another study with a high effect size (ES = 1.22), conducted by Poland, Van Oers and Terwel (2009), investigated the impact of dynamic representations on kindergarten students' math achievement. Dynamic representations provided more opportunities for having the learners explore their structures, thus generating a higher engagement factor and consequently higher learning effects. A positive learning effect of students' explorations was also advocated by Lesh and Harel (2003), who concluded that such situated learning enhances the processes of mathematical modeling that can play a vital role in developing students' scientific curiosity and they are problem-solving beyond the primary school level.

Analysis of Moderator Effects

The process of a further synthesis of the studies' features allowed for identifying the following moderators: treatment length, mode of introducing the representations, grade level, and content standards. The moderators were further disaggregated by their levels. Where applicable, the levels within the moderators were contrasted, and inferences on differences were made. The following criteria were applied to disaggregate the moderators.

Treatment length. The treatment length followed a partition established by Xin and Jitendra (1999): short – less than one week; intermediate – between 1 week and one month; and long - more than one month.

Mode of representation induction in the lesson cycle. This moderator followed operational roles of representations and contained two levels: concept introduction and problem-solving.

Grade level. The large range of grades was distributed into two levels according to standard classification (NCTM, 2000). The lower group level encompassed all students from Pre-K to Grade 3, and the upper level included Grades 4 and 5.

Content standards. This moderator reflected general standards examined in the studies that were clustered into the following: number and operations, proportions, and geometry. A summary of the weighted effect sizes is presented in Table 3.

Table 3. Summary of subgroups' moderator effect sizes

Moderator and Levels	N	ES	SE	95 % CI	
				Lower	Upper
Grade Level					
Lower: Pre-K through 3	6	0.60	0.08	0.45	0.76
Upper: 4-5	7	0.47	0.07	0.33	0.60
Representation Type					
Pictorial	6	0.45	0.06	0.32	0.57
Schemata based	5	0.49	0.09	0.31	0.67
Concrete	1	0.71	0.29	0.05	1.20
Other	1	2.00	0.31	1.38	2.63
Treatment Length					
Short	5	0.46	0.07	0.31	0.61
Intermediate	4	0.53	0.10	0.33	0.72
Long	4	0.60	0.10	0.40	0.80
Content Standard					
Numbers and operations	10	0.45	0.06	0.34	0.56
Geometry	2	1.61	0.22	0.17	0.24
Ratio and proportions	1	0.71	0.29	0.05	0.20
Mode of Induction					
Concept Introduction	7	0.68	0.07	0.54	0.82
Problem-solving	6	0.49	0.08	0.34	0.64

Note. N = number of participants, ES = effect size, SE = standard error.

The computing of the mean subgroup effect sizes provided a basis for answering more detailed research questions. When compared by grade level, the effect of using representations was higher in Pre-K through Grade 3 than in Grades 4-5. This conclusion might be supported by the fact that as students' progress with learning math concepts, they learn more abstract semantics that might be difficult to embody in representations, for instance, the idea of fraction division. Students can follow the initial and final stage of the process. However, the diversity of the methods of dividing that is embodied by the syntax of division along with the various representations of rational expressions might not be entirely comprehended and thus it needs more clarity.

When mediated by the type of representation, *concrete* and *others* produced the highest effect sizes; yet, their significance could not be fully apprehended because each subgroup was represented by a single primary study. When pictorial representations (ES = 0.45) and schemata-based representations (ES = 0.49) were contrasted, schemata representations showed a higher impact on student learning, which supports the findings of other scholastic research (e.g., Jitendra et al., 2007; Terwel, Van Oers, Van Dijk, &Van den Eeden, 2009; Xin et al., 2011). Overall, schemata-based representations and their applications emerged as the main type of representations supporting problem-solving. According to Owen and Sweller (1985), a schema is a general cognitive structure that allows the learner to categorize the problem and then apply specific tools to solve it. A moderate effect size (ES = 0.49) indicates that this learning strategy helps students understand underlying mathematical ideas in given word problems and solve them. Hiebert and Carpenter (1992) posited that while developing the schemas, students activate a complex network of concepts stored in their long-term memory. Furthermore, the networks constitute the model that will be called an internal representation of the domain embodied by an external representation. As Xin et al. (2011) suggested, instead of telling students, for instance, the numerical magnitude of the unit rate, e.g., ten apples per basket, demonstrating students a real concrete representation along with its symbolic mathematical model will better support the conceptual understanding and its mathematical embodiment.

How should representations be furnished to effectively develop the conceptual networks? Learners can be provided with the representations, or the representations can be derived by the learners under the teacher's guidance. It is inferred from this study that providing students with opportunities to derive the representations deems to be a more effective teaching strategy because it allows the learners to retain the concepts longer and apply them in new situations more frequently.

An interesting direct variation was observed when the effect sizes were contrasted with treatment lengths. It became apparent, from examining this relation, that the longer the treatment, the higher the effect size (ES = 0.46 for short treatments, ES = 0.53 for intermediate, and ES = 0.60 for long). This result provides support for applying representations in classes daily.

Concerning content standards, geometry representations yielded a higher effect size (ES = 1.61). This result reflects the visual nature of content in this branch of mathematics, which by virtue is rooted in representations. The analysis of the concluding subgroup—mode of inducing in the lesson cycle—allowed contrasting the effect sizes of using representations to support conceptual understanding and problem-solving. It is apparent that representations are more effective with concept introduction (ES = 0.69) than problem solving (ES = 0.49). Thus, one could conclude that supporting concept introduction with representations builds a stronger network of impulses in students' long-term memory.

Summing all these findings led to the formulation of a classroom setting that would generate the highest learning effect sizes. It seems that using concrete representations to introduce geometry concepts in Pre-K through Grade 3 would yield the highest learning effects.

The research findings also allow for the formulation of recommendations for effective representations. Fujimura (2001) concluded that representations should share similar features as the target domain and must be manipulative so that children can explore and uncover embedded math structures by themselves. He further suggested that representations should be designed in a way that they develop children's creativity in constructing mathematical models. Casey et al. (2008) found that students retain mathematical knowledge if the knowledge is embedded in a story context. Developing mathematical knowledge through sequenced mathematics problems related to the storyline is also suggested by the researcher of the meta-analysis. Booth and Siegler (2008) highlighted accuracy and transparency of representations as a significant factor affecting students' mathematical learning in early grades, whereas Poland et al. (2009) brought forth the idea of using dynamic representations to support the processes of arithmetic operations.

As mathematics seeks to develop students' concise, abstract thinking, the results of this synthesis show that it also needs to reflect on representations that students use in daily life and whose contents are adequate to their experiences. Presenting artificially created representations that do not adhere to students' experiences might disconnect mathematics concepts from the realm and rather support the notion that mathematics is an abstract subject.

General Conclusions

The findings of this study support the following hypothesis: representations help Pre-K through fifth-grade students learn and apply abstract math concepts, especially when such representations are applied to support new concept understanding and students' problem-solving skills. Certain limitations and recommendations for further research emerged from this study, as discussed below.

Threats to Research Validity

The primary parameter limiting the study findings was a lower-than-expected pool of primary studies that satisfied the conditions to be meta-analyzed. The validity of the study computations was supported by double research data coding at the initial and concluding stages of the study process. Any potential discrepancies were resolved. Although strictly specified, the literature search was undertaken with broader conceptual definitions in mind that allowed for, as suggested by Cooper (2010), adjustment of the definitions and strengthening of the literature relevance. Thus, as the initial literature search revealed that representations in Pre-K through Grade 5 are often used to support problem-solving, the term *problem solving* was then used to locate more studies.

Schemata as a Major Type of External Representations

Among different representations (see Table 1) schemata-based representation and their applications emerged as the most commonly used to support problem-solving. According to Owen and Sweller (1985), a schema is a general cognitive structure that allows the problem solver to categorize the problem and then apply certain tools to solve it. A moderate effect size (ES = 0.49) indicates that this learning strategy helps students understand underlying math ideas in given word problems. Hiebert and Carpenter (1992) posited that in the process of developing the schemata, students' thinking blends a complex network of concepts in one coherent picture. Furthermore, the networks constitute a mental model that will be called an internal representation of the domain imaged by an external representation. The conceptual networks can be developed either by representations provided by the teacher or by representations derived by the learners under a teachers' guidance.

Is having students use schemata sufficient to have them learn the holistic picture of the meaning of this mathematical representation? Several researchers concluded that once children are exposed to certain representations – for instance, schematic representations to solve problems – they retain those methods and apply the schemas regardless of age (Coquin-Viennot & Moreau, 2003). Some scholars noted (e.g., Castle & Needham, 2007), this idea cannot be overemphasized; children also need some *working space* to analyze problems and devise their ways to solve the problems with the *support* of provided schemata. Thus schemata should be perceived as suggestions for mathematization of certain patterns not as fixed formulas to use. It seems that more research should focus on having students recognize the type of scientific underpinning of the problem that students should apply to determine the principles embedded in a given word problem.

Hiebert and Carpenter (1992) proposed four semantic categories (schemata) for arithmetical operations that are: *change, combine, compare,* and *equalize.* Using these schemata to model *story problems* allows certain flexibility, for example, in some cases can be perceived as *compare*, or *compare* can suffice to *combine*. Emphasizing the schemata to reach the final solution reduces learners' opportunities to explore and be immersed in the process of analyzing the problem structure. There can also be cases when two or more schemata can be used in successions. For example, in order to *compare*, students might need to *combine* similar elements first. Thus students should be allowed to exhibit flexibility in applying the schemata and interpret them. However, that the primary meaning of each should be consistently executed. To illustrate that consider the following problem discussed by Jitendra et al., (2007): *Music Mania sold 56 CDs last week. It sold 29 fewer CDs last week than this week. How many CDs did it sell this week?* This problem was intended to support the idea of *compare.* There is merit to use the schema of *compare* in this problem, but is the schema *compare* the most representative to mathematize the process of selling the CDs? The problem mentioned two events happening at two different time instants referring to similar objects, can then the learner be directed to considering rather finding the difference? Thus would the schemata of *change* better describe the process and elicit its solution? It seems that referring students to *compare* gears their thinking toward the output of the problem thus finding the final product, not toward the principal process, *the change* that supported the process of reaching the output. By directing students' attention to the problem output, the phase of problem analysis is reduced. Referring to the problem context and considering the definition of change as *Change = Final value – Initial value,* and solving for *Change,* one will receive *Change = This week sells – Last week sells.* Substituting the given values results in *29 = This week sells – 56*, that leads further to *This week sells = 56 + 29* which leads to the conclusion that *Music Mania* sold 85 CDs. With the implementation of *change,* the representation involved negative numbers that perhaps were not intended in Jitendra's study. Thus to further discuss the applicability of this problem to Grade 3 math curriculum, the problem would have to be redesigned, however providing students with the flexibility of exercising the underlying *process* that is missed is worth further research. Zooming further change in quantity values is concluded by subtracting the initial value from the final value: *Change = Ending – Beginning*. This standard definition of change is applied not only in mathematics to calculate, for example, instantaneous or average rate of change (e.g. Stewart, 2006) but also in sciences, especially in physics where the concept of change is often used to calculate change of temperature, or object's displacement (e.g., Giancoli, 2005).

One might be interested in learning how the schemata of *change* are induced in the literature. The idea of using *change* was introduced by Marshall (1995) see Figure 3 and was modeled by the following problem; *Jane had 4 video games. Then her mother gave her 3 video games for her birthday. Jane now has 7 video games.*

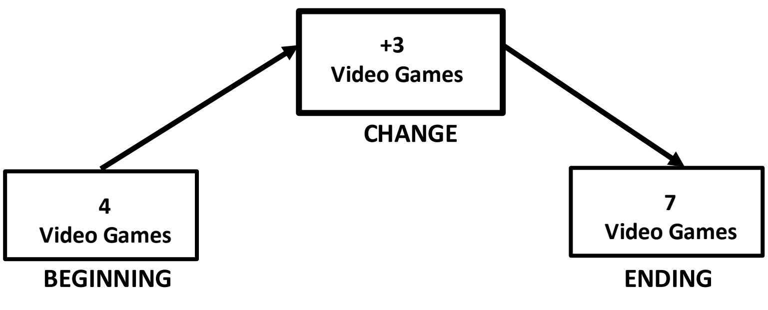

Figure 3**.** Representation of *change* inspired by Marshall (1985).

Change in quantities values is concluded by subtracting the initial value from the final value: *Change = Ending – Beginning*. This standard definition of change is applied not only in mathematics to calculate, for example, instantaneous or average rate of change (e.g. Stewart,

2006) but also in sciences, especially in physics where the concept of change is often used to calculate change of temperature, or object's displacement (e.g., Giancoli, 2005). This equation can be rearranged to reflect Marshal's idea *Beginning + Change = Ending.* However, the rearranged form is not aligned with the fundamental principle of the *process of change* that seems to be the core idea of the problem. If the schema of *change* were to be used, then perhaps the diagram could have been redesigned to reflect on the difference in the quantity amount that represents the *change*.

These two examples were brought up to signify a need for verifying interdisciplinary consistency of the interpretations of the fundamental concepts that are meant to support problem-solving in K-5 mathematics. It is understood that the equations symbolizing the schemata can be rearranged and executed with a dose of flexibility. What stages were being used would depend on individual perception, yet general foundations for problem analysis would perhaps require more consistency. Perhaps establishing fewer schemata and letting students manipulate on them to reflect the process of a given problem could be an alternative avenue to pursue? The mathematical operations behind calculations of *change, combine, compare,* and *equalize* are very fundamental in sciences, and it seems that understanding their core meanings might have a profound impact on students success on problem-solving not only at an elementary but also at a high school level and beyond.

Looking Ahead: Linking the Representations

Cheng (1999) proposed four learning stages that can help students in developing conceptual understanding through using representations: domain, external representation, concept, and the internal network of concepts. While moving from one stage to another to reach the internal network, the learner is immersed in four processes: observation, modeling, acquisition, and integration. Except the study conducted by Rittle-Johnson, Siegler, & Alibali (2001) and Terwel et al. (2009), the majority of the gathered research did not explicate on these processes, focusing instead on applying fixed models without discussing their possible modifications.

It seems that possessing the right representation does not suffice for an understanding. To confirm an understanding, one needs to be able to put this representation through its paces, explaining and predicting novel cases. Thus, to have an understanding of a representation is to be in a state of readiness, taking the representation as a point of departure in the solution process, not as an unquestionable formula a representation. Terwel et al. (2009) proved that having students explore and modify given representations produced the highest effect size. This can be supported by the effects of induced math modeling phases that allowed the students to link representations with the constraints of real scenarios (Sokolowski, 2018).

Applying representations often creates exploratory learning environments (English & Watters, 2005) that consequently can be guided by inductive or deductive inquiry processes. Thus, other themes worthy of a further investigation emerged; should the use of representations to be organized inductively, as suggested by Nunokawa (2005)? How do elementary school students perceive these two major scientific inquiries? Are these inquiries rooted in virtues of mathematical representations, or content-domain? Having students develop principles of representations by identifying commonalities due to applications and use such representations to model other contexts beyond the boundary of a math classroom would be an interesting pursuit for future studies.

Bridging Representations Used at Elementary and High School Levels

There are other questions can be generated from this study, for example; how does the use of representations evolve as students' progress with their mathematics classes, especially schemata-based that dominate problem-solving in Pre-K through Grade 5. Fuchs, L., Fuchs, D., Finelli, Courey, & Hamlet (2004) suggested using schemata more extensively for problem-solving also at the high school level, especially targeting students with learning disabilities. Having high school students derive processes of transitioning from, for example, proportion to a linear or rational function or from percent rate to an exponential function seem like valuable topics to explore.

Another conclusion calls for extending the idea of using schemata to sciences and other subjects in a consistent manner that will carry out their general principles. This transition would help broaden the meanings and consequently built a stronger image of these representations in students' long-term memories. Do students experience applications of similar representations in their science classes? Should these main avenues of knowledge acquisition depend on the nature of the representation (schemata or pictorial) or their general purpose? Further research in these areas is needed, and it is believed that this paper provides some prompts for such actions.

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Corresponding author: Andrzej Sokolowski
Contact email: Andrzej.Sokolowski@lonestar.edu

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