*MIER Journal of Educational Studies, Trends & Practices*
*November 2017, Vol. 7, No. 2 pp. 121-134*

# Blended Learning Environment: An Approach to Enhance Students's Learning Experiences Outside School (LEOS)

Sandhya Devi Coll and David Treagust

*This paper reports on blended learning environment approach to help enhance students' learning outcomes in science during Learning Experiences Outside School (LEOS). This inquiry took the nature of an ethnographic case study (Lincoln & Guba 1985; Merriam, 1988), and sought to establish ways of enhancing students' LEOS. The context of the inquiry was a private rural religious secondary school in New Zealand. The New Zealand Science Curriculum is based on a constructivist-based view of learning which provides opportunities for a number of possible learning experiences for science, including LEOS, to enrich student experiences, motivate them to learn science, encourage life-long learning, and provide exposure to future careers (Hofstein & Rosenfeld, 1996; Tal, 2012). However, to make the most of these learning experiences outside the school, it is important that adequate preparation is done, before, during and after these visits. Sadly, the last two decades of research suggest that activities outside school such as field trips have not necessarily been used as a means to improve school-based learning (Rennie & McClafferty, 1996). This inquiry utilised an integrated online learning model, using Moodle, as a means to increase student collaboration and communication where students become self-directed, negotiate their own goals, express meaningful ideas and display a strong sense of collective ownership (Scanlon, Jones & Waycott, 2005; Willett, 2007). The digital space provided by Moodle allows students significant autonomy which encourages social interactions and this promotes learning and social construction of knowledge (Brown, Collins, & Duguid, 1989; Lewin, 2004).*

**Keywords:** Social Constructivism, Co-construction, Integrated Online Learning Model, New Media Literacies (NML)

*Sandhya Devi Coll*
*Research Scholar, Curtin University, Perth, WA, Australia*

*David Treagust* ✉
*Director Research, STEM Education Research Group*
*Curtin University, Perth, WA, Australia*
*Email: D.Treagust@curtin.edu.au*

## INTRODUCTION

Learning experiences outside school (LEOS) is an excellent way to enrich students learning experiences, motivate them to learn science, encourage lifelong learning and also expose them to future careers (Bamberger & Tal, 2007; Hofstein & Rosenfeld, 1996; Tal, 2012). These informal settings are idiosyncratic, and learning occurring at these sites depends on the students' personal and social context in which learning takes place (Rennie & Johnston, 2007). Falk and Dierking (2000) stress the point that learning at Informal Science Institutions (ISIs) is a slow process and say it is largely dependent upon the student's prior experiences and knowledge. Consistent with this, in the last two decades some authors have concluded that LEOS has not seen to be contributing towards conceptual learning of science for a variety of reasons (see e.g., Rennie & McClafferty, 1996).

The literature goes on to suggest that in order to enhance the learning outcomes in science, it is important to integrate out-of-school learning with classroom practice (Orion & Hofstein, 1994). This could be achieved if teachers actively engage in pre- and post-visit planning with strong curriculum links (Anderson & Zang, 2003; Rennie & McClafferty, 1995; Tofield, Coll, Vyle & Bolstad, 2003). Some authors argue that lack of integration of field-based experience with students own prior experiences during planning means students are rarely engaged in small group activities during LEOS (Morag & Tal, 2009; Tal, 2012). Learning at ISIs is different from that in a classroom, and to maximise such opportunities, there is a need for defined objectives and the use of appropriate pedagogies. The tasks designed to facilitate learning during LEOS should allow for scaffolding of students' prior experience and knowledge, have structure but some freedom of choice, should be student-centred and include task-centred activities. It is important to take full advantage of LEOS and provide opportunities for students to socially, emotionally and cognitively interact with others and artefacts to promote (lifelong) learning.

## HOW STUDENTS LEARN

There has then been a shift in thinking about how students learn. This change to how we view learning resulted in worldwide curriculum reform, a shift from formal curricular in many countries to developing learner-centred curricular where there is an integration of formal, non-formal and informal instructions. That is, providing more choices of what is to be studied, where these studies are done, and providing opportunities for students to become responsible for their learning. An example of how some countries have tried to shift away from traditional pedagogies is in New Zealand, the context for this inquiry. New Zealand began substantial curriculum reforms in 1991, when the science education system in New Zealand went through a massive redevelopment programme, with curriculum statements replacing syllabuses (Ministry of Education [MoE], 1993). The current curriculum provides a framework of learning of science for all students, and places strong emphasis on teaching approaches based on a learner centred and constructivist-based view of learning, which requires teachers to provide opportunities for a variety of learning experiences for science.

Therefore, the focus in today's science classrooms is finding ways to improve teaching and enhance learning outcomes through a variety of tools. ISIs allows students to negotiate meaning and find answers to complex questions (Ash & Wells, 2006). Also students engage in dialogues with each other and with ISI staff in multiple ways, and are provided with a variety of opportunities for sensory experiences that help students to develop a better understanding of the science taught in the classrooms and relate this to experiences around them (Ash, 2002). There is however a growing body of literature on the value of inclusion of Web 2.0 Technologies such as Moodle in science classrooms, where students can enjoy some autonomy in these new digital spaces and take an active role in choosing what, where, how and with whom they learn without time and curriculum constraints.

## Research Aims

This inquiry sought to examine the potential of an integrated online learning model to improve the learning of science during LEOS. The motivation for the research was the literature reports that LEOS properly facilitated has the potential to stimulate curiosity among students and contribute to improved learning outcomes. But in order to support and explore these collaborations, there is need for the use of support such as the Learning Management System (LMS), Moodle, through which we might stimulate learning in a variety of ways and develop a constructivist or learner-centered learning environment. The overall aim of this work was to ascertain how the learning of science in out-of-school settings might be enhanced by the use of an integrated online learning model.

## Theoretical Framework

This inquiry looks at the integration of students' learning experience in classrooms and during LEOS, using a LMS, Moodle, to help enhance the learning outcomes in science. Recent research points to a need to integrate

LEOS with teaching programmes and use out-of-school activities to complement, not replace, learning activities in classrooms (Falk & Dierking, 2012; Rennie, 2007; Rennie & McClafferty, 1995). Tofield et al. (2003) stress that there is often lack of teacher preparation, and Tal and Steiner (2006) assert that teachers mainly play a passive role during LEOS, such as managing student behaviour rather than actively mediating, encouraging and questioning students' findings. Anderson, Lucas, Ginns and Dierking, (2000) and Bolstad, (2001) report that in order to enhance learning outcomes from out-of-school activities, teachers should plan accordingly, linking out-of-school visits to specific curriculum objectives, include some degree of choice, and linking these objectives directly to activities during the visit. This stress on the importance of well-structured LEOS is supported by Orion and Hofstein (1994), who say strong links provide meaning to abstract science ideas studied in the classroom.

For the past 30 years, there have been more than 400 national reports calling for fundamental changes in how we educate our children, particularly in mathematics and science (Hawley, 2002; Hurd, 1994; NRC, 1996). These reports call for reforms aimed at developing scientific habits of mind or ways of thinking, by having students take a more active role in learning of science content that has current relevance. So, while it is important to engage in LEOS, it is equally important to establish environment where useful information is generated and intertextuality of multiple data sources are used to develop more meaningful and integrated knowledge (Knorr-Cetina, 1992; Roth, 1995; Spier-Dance, Mayer-Smith, Dance & Khan, 2005; Varelas & Pappas, 2006). Social constructivism underpins the research of this inquiry. Driscoll (2000) and Wertsch (1991) say that the social presence is a critical component of learning, together with, transactional distance and social affordance. They argue that these three elements 'conspire' to create the right conditions for teaching and learning, and this can constructively align in a LMS.

NML is then a theoretical framework that has been used to explore the participation opportunities made available through these emerging technologies, such as Web 2.0 Technologies. NML are used for three key purposes, namely (1) accessibility to a variety to people and resources, (2) connectivity helps as a social tool to share information and ideas through the webbed structure and finally (3) multiple modalities for expanding the mediating practices which helped construct relationship (Gee, 2003; Hull & Schultz, 2002; Lankshear & Knobel, 2008; Leuhmann & Frink, 2012). That is, the focus of NML is that knowledge is shared through collaboration and distributed expertise and authority. Perhaps, an alternative could be to draw upon the best from both teaching face-to-face and e-learning, what is often referred to as blended learning. This inquiry only considers affordances of one

Web 2.0 Technologies namely wiki which is used in schools today.

## RESEARCH METHODOLOGY

The methodology employed in this inquiry was a qualitative case study approach, where multiple interviews and observations were conducted over a considerable length of time (ca. 12 months). This inquiry was intended to support science teachers of Year 11 students in a private religious secondary school and explore issues of intent, use, and perceived value of the use of Moodle, when taking learning outside school. This inquiry explored the emerging wiki affordances which use the Internet, and help in communication, collaboration and co-construction of knowledge in an informal learning environment. Pre-visit preparation used wiki to encourage social interactions, develop familiarity with the tool and establish an e-community. The wiki pages were also used to introduce students to the topic, Astronomy. It was an opportunity to identify student's prior knowledge in this subject area, a key aspect of constructivism. The classroom lessons continued to be used for formal learning, where students used text books and teacher guidance to develop a deeper understanding of this topic. Data sources in this case included one year's of students' postings on wiki, interviews with the facilitating teachers, Head of Faculty (HoF), ISI staff and students' assessment results. Post-visit planning was intended to do the following: (1) encourage teachers' in creating additional forms of participation and increase student exposure time with content; (2) wiki was used as pedagogical tools and in ways that likely afforded social benefits; and (3) encouraged both teachers and students to invest more time in communicating through this activity.

The inquiry sought to provide insights on how to better plan for LEOS and integrate with classroom practice, using an integrated online learning model. This paper discusses the third phase of a larger study which involved 65 Year 11 (15 years old) students and 10 teachers.

## RESEARCH FINDINGS

### Pre-Visit Observations:

The visit to an ISI, Observatory (a pseudonym), involved pre- and post-visit planning which also included some free choice learning and induction to using wiki feature of Moodle. The students were required to complete compulsory internal assessment at Level 1 Science, called AS90954: Lunar- Our Moon. Semi-structured focus group interviews with students suggested that they appreciated going on visits outside the school which helped them see “real things” and “help enhance conceptual understanding of science learnt in class". Students' wiki postings:

**Phases of the Moon**

From the Earth, we can only see the part of the moon that the sun illuminates because we see it at different angles as it rotates around the Earth.

Also, apparently the moon's cycle affects our emotions, mood and behaviour - I'm not sure whether that's a bit silly to add in!! The Earth's orbit around the Sun...

The Earth is closest to the sun on January 3rd and this point in the Earth's orbit is called perihelion.

The Earth is farthest away on July 4th and this point in the Earth's orbit is called aphelion.

Interviews with teachers suggested that the internal assessment (AS90954), was not an easy topic to teach as well as the "students lacked enthusiasm in the former years, which negatively affected their results" (Teacher Interviews, 03 October 2014). Mixed abilities grouping and having a student leader ensured support for all members. Students encouraged each other to bring resources from home and making the print friendly page of wiki compulsory maximised student online participation. Teachers also adopted a blending learning classroom environment where students watched videos on Moodle followed by class discussions, and then made wiki postings which were moderated by their teachers.

**During the Visit:**

*Interviewer:* So what activity have you planned for them?

*Mr. Daniel (ISI Staff):* The teachers want me to discuss the types of telescopes which are used to view celestial bodies. Also, they want me to show videos on the effect of moon on tides, as well as rotation and revolution of the Earth around the sun. I have also booked in the telescope room for them, where they will see and use a real telescope. We will use it to see the sun, so I have to put a filter in.

*Interviewer:* So where would they be watching the video?

*Daniel:* Well, we have a classroom where I will also use Power Point, videos and role-play to help reinforce these concepts so they can retain information for their assessment task and it will also give them opportunity to ask me specific questions. They also have hands-on activities to be done in groups as this will encourage more dialogue, between them and they could also ask me anything they need help in.

**Post-visit Observations: Students' wiki postings**

**Phases of the moon**

From the Earth, we can only see the part of the moon that the sun illuminates because we see it at different angles as it rotates around the Earth.

Also, apparently the moon's cycle affects our emotions, mood and behaviour - I'm not sure whether that's a bit silly to add in!! The Earth's orbit around the Sun...

The Earth is closest to the sun on January 3rd and this point in the Earth's orbit is called perihelion.

The Earth is farthest away on July 4th and this point in the Earth's orbit is called aphelion.the moon moves across the sky about 15 degrees per night

when the sun & the moon are on opposite sides of the earth, it is full moon.

There are eight (or nine) phases of the moon that are:

1) New Moon - Dark, not visible

2) Waxing Crescent

3) First quarter - half moon

4) Waxing gibbous

5) Full moon - see whole circle

6) Waning gibbous

7) Third quarter - other half-moon opposite to the first quarter.

8) Waning crescent

Back to new moon is a full cycle.

The student performance in Table 1 shows a substantial improvement in their results. The HoF attributed this to the integrated online learning model used for curriculum delivery. She stated that "the notes and videos on their own are not as effective as when students hear from ISI staff and collaborate with each other what they had learnt" (Interview with Head of Faculty, 03 October 2014).

**Table 1**

**Summary of Assessment Results for *AS90954: Lunar- Our Moon, between 2013 and 2014.**

| Year | Not Achieved | Achieved | Achieved at Merit | Achieved at Excellence |
|---|---|---|---|---|
| 2014 | 0 | 13 | 35 | 52 |
| 2013 | 20 | 7 | 43 | 30 |

* AS90954: Is an internal assessment which helps to measure the achievement objectives as outlined in an achievement standard for Astronomy - a contextual strand called Making Sense of Planet Earth and Beyond.

## DISCUSSION

The New Zealand Curriculum recommends that teachers create learning environments, where there is a learning partnership through learning conversations (Ministry of Education [MoE], 2007). This inquiry adopted these recommendations by engaging in LEOS and facilitating learning using the wiki feature on Moodle. A change in pedagogical approach was needed to help integrate learning, in order to enhance the learning outcomes in science during LEOS. The findings from this inquiry are consistent with those of other studies involving LMS to afford new forms of participation. Moodle, used as a cognitive tool also has a positive effect on the affective domain. The teachers were keen to diversify their teaching approaches in order to improve students' achievement rates for this achievement standard which was not satisfactory in the last two years. The students were motivated about visiting an ISI, the Observatory, getting opportunities for some free choice learning, and being able to collaborate digitally within groups, before and after the visit. That is, they were aware of their purpose for engagement during LEOS, accessed multimodal resources, and shared their findings via wiki. These finding take into consideration some concerns shared by Gee (2003, 2004) on factors which may inhibit the affordances of digital technologies getting translated into classrooms. However, the results are consistent with those of Annetta, Murray, Laird, Bohr and Park, (2008) and Leander (2007) who state that teacher attitude and belief, promotes social affordances, allowing students to assume new roles and provide autonomy in the co-construction of knowledge.

A key outcome of this inquiry is the multimodality feature of Web 2.0 Technologies, and using them in productive ways, which supports the constructivist style of learning (Downes, 2005). It offers a unique platform along with a number of features, a focus of NML framework, where knowledge is shared through collaboration and distributed expertise and authority (O'Neill, Wagner & Gomez, 1996). Moodle was used by teachers as well as peers to create social presence, reduce transactional distance where students shared learning in a way which was dialogic, and promote social affordances via e-moderating. Information in text and graphical formats resided in the virtual space, which was accessed by students to create their own texts and make postings on the wiki site either supporting or adding a different view point. This act of multi-mediating, that is making intertextual links helps students to map information by drawing inferences from multiple sources and re-contextualising them to make meaning, which is shared by the group (Gernsbacher, 1990; Hayes-Roth & Thorndyke, 1979). Doneman (1997) and Lankshear and Knobel (2003) state that it is not the final product which students write, but the process adopted in producing it that is important. There is then considerable commonality between the present data and with the findings of Gernsbacher (1990), Hayes-Roth and Thorndyke (1977, 1979) who observe that integration of information is a cognitive process, where intertextuality of information enables high order thinking.

While majority of the studies in the literature, caution that intertextual integration does not happen to the degree that we would like, findings reported here are different from those reported by Hartman (1995), Van Meter (2001), Van Meter and Garner (2005), Tabachneck-Schijf and Simon (1998) and Thesen (2001). This different finding could be due to the fact that the present study involved students who expressed widespread appreciation for having opportunities to help co-construct knowledge within their group using multiple sources. Another feature which enabled intertextual integration was the use of mixed ability groups where students shared their interpretations using multimodal resources. It is important to note that the need to collect as much information on the 'print-friendly sheet' of wiki in order to write the final assessment report was a catalyst for such active online collaboration. Also, using blended classes as compared to traditional ones or only online, seemed to have a positive influence on students' attitude. They felt supported and reassured, which helped them to remain focussed. This was somewhat different to the findings reported by Fjermested, Hiltz and Zhang (2005), who reported mixed results when students only collaborated online. The data from this phase of inquiry revealed that a blended learning environment fostered better learning outcomes, as showed by student assessment results in Table 1.

## CONCLUSION

It can be concluded that LEOS helps provide context for learning where students learn via social negotiations. However, students learning outcomes can be improved by adequately preparing for both pre- and post-visit activities, which have strong curriculum links, having enthusiastic ISI staff, including some free choice and integrating learning using Moodle. There are only few studies reported in the research literature which measure the impact of LMS, like Moodle, a Web 2.0 Technologies, on student learning outcomes (Coates, James & Baldwin, 2005; DeNeui & Dodge, 2006). This inquiry, however, effectively integrated the three key features for teaching and learning via LMS, which are social presence, transactional distance, and social affordances, which were based on constructivist teaching principles, helped motivate students, and linked their findings to the real world. The results evidenced an improvement in students' performance outcome in the achievement standard (AS90954). It must be noted, however, that these outcomes are strongly dependent on the multi-faceted roles played by teachers and students.

## References

Anderson, D., Lucas, K. B., Ginns, I. S., & Dierking, L. D. (2000). Development of knowledge about electricity and magnetism during a visit to a science museum and related post-visit activities. *Science Education*, *84*, 658-679.

Anderson, D., & Zhang, Z. (2003). Teacher perceptions of field trip planning and implementation. *Visitor Studies Today*, *6*(3), 6-12.

Annetta, L., Murray, M., Laird, S., Bohr, S., & Park, J. (2008). Investigating students' attitudes towards asynchronous, online graduate course in a multi-user virtual learning environment. *Journal of Technology and Teacher Education*, *16*(1), 5-34.

Ash, D. (2002). Negotiations of thematic conversations about biology. In G. Leinhardt , K. Crowley & K. Knutson (Eds.), *Learning conversations in museums* (pp. 357-400). Mahwah, NJ: Erlbaum.

Ash, D., & Wells, G. (2006). Dialogic inquiry in classrooms and museums. In Z. Bekerman, N. C. Burbles & D. Silberman-Keller (Eds.), *Learning in places: The informal education reader* (pp. 35-54). New York, NY: Peter Lang.

Bamberger, Y., & Tal, T. (2007). Learning in a personal-context: Levels of choice in a free-choice learning environment in science and natural history museums. *Science Education*, *91*, 75-95.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and culture of learning. *Educational Researcher*, *18*(1), 32-42.

Bolstad, R. (2001, July). *The actual and potential role of science and technology centres in New Zealand primary science and technology education*. Paper presented at the 32nd annual conference of the Australasian Science Education Research Association. Sydney, Australia.

Coates, H., James, R., & Baldwin, G. (2005). A critical examination of the effects of learning management systems on university teaching and learning. *Tertiary Education and Management*, *11*, 19-36.

DeNeui, D. L., & Dodge, T. L. (2006). Asynchronous learning networks and student outcomes: The utility of online learning components in hybrid courses. *Journal of Instructional Psychology*, *33*(4), 257-259.

Doneman, M. (1997). Multimediating. In C. Lankshear, C. Bigum, C. Durrant, B. Green, E. Honan & W. Morgan (Eds.), *Digital rhetorics*: *Literacies and technologies in education, current practices and future directions* (pp. 131-148). Canberra, Australia: Department of Employment, Education, Training & Youth Affairs.

Downes, S. (2005). *E-learning 2.0*. Retrieved from http://www.elearning.org/subpage.cfm? section=articles&article=29-1.

Driscoll, M. (2000). *Psychology of learning for instruction*. Needham Heights, MA: Allyn & Bacon.

Falk, J., & Dierking, L. (2000). *Learning from museum*: *Visitors experience and the making of meaning*. Walnut Creek, CA: Alta Mira.

Falk, J. H., & Dierking, L. D. (2012). Lifelong science learning for adults: The role of free-choice experiences. In B. J. Fraser, K. G. Tobin & C. J. McRobbie (Eds.), *Second international handbook of science education* (vol. 2, pp. 1063-1079). Dordrecht, The Netherlands: Springer.

Fjermested, J., Hiltz, S. R., & Zhang, Y. (2005). Effectiveness for students: Comparisons of 'in seat' and ALN courses. In S. R. Hiltz & R. Goldman (Eds.), *Learning together online*: *Research on asynchronous learning networks* (pp. 39-80). Mahwah, NJ: Erlbaum.

Gee, J. P. (2003). *What video games have to teach us about learning and literacy*. New York, NY: Palgrave MacMillan.

Gee, J. P. (2004). *Situated language and learning*. New York, NY: Routledge.

Gernsbacher, M. A. (1990). *Language and comprehension as structure building*. Hillsdale, NJ: Lawrence Erlbaum.

Hartman, D. (1995). Eight readers reading: The intertextual links of proficient readers reading multiple passages. *Reading Research Quarterly*, *35*(2), 281-282.

Hawley, D. (2002). Building conceptual understanding in young scientists. *Journal of Geoscience Education*, *50*, 363-371.

Hayes-Roth, B., & Thorndyke, P. W. (1979). Integration of knowledge from text. *Journal of Verbal Learning and Verbal Behaviour*, *18*(1), 91-108.

Hofstein, A., & Rosenfeld, S. (1996). Bridging the gap between formal and informal science learning. *Studies in Science Education*, *28*, 87-112.

Hull, G., & Schultz, K. (2002). *School's out!: Bridging out-of-school literacies with classroom practice*. New York, NY: Teachers College Press.

Hurd, P. (1994). New minds for a new change: Prologue for modernizing the science curriculum. *Science Education*, *78*, 103-116.

Knorr-Cetina, K. D. (1992). The couch, the cathedral, and the laboratory: On the relationship between experiment and laboratory in science. In A. Pickering (Ed.), *Science as practice and culture* (pp. 132-138). Chicago, IL: University of Chicago Press.

Lankshear, C., & Knobel, M. (2008). *New Literacies: Everyday practice and classroom learning* (2nd ed.). Berkshire, UK: McGraw Hill.

Lankshear, C., & Knobel, M. (2003). *New literacies*: *Changing knowledge and classroom learning*. Buckingham, UK: Open University Press.

Leander, K. M. (2007). You won't be needing your laptops today: Wired bodies in the wireless classroom. In M. Knobel & C. Lankshear (Eds.), *A new literacies sampler* (pp. 25-48). New York, NY: Peter Lang.

Lewin, C. (2004). Access and use of technologies in the home in the UK: Implications for the curriculum. *The Curriculum Journal*, *15*(2), 139-154.

Leuhmann, A. L., & Frink, J. (2012). Web 2.0 Technologies, new media literacies, and science education: Exploring the potential to transform. In B. J. Fraser, K. G. Tobin & C. J. McRobbie (Eds.), *Second international handbook of science education* (vol. 2, pp. 823-838). Dordrecht, The Netherlands: Springer.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry.* Newbury Park, CA: Sage.

Merriam, S. B. (1988). *Case study research in education.* San Francisco, CA: Jossey-Bass.

Ministry of Education. (1993). *Science in the national curriculum*. Wellington, New Zealand: Learning Media.

Ministry of Education. (2007). *The New Zealand curriculum framework*. Wellington, New Zealand: Government Printer.

Morag, O., & Tal, T. (2009, April). *Multiple perspectives of out-of-school learning in various institutions.* Paper presented at the annual meeting of the National Association for Research in Science Teaching. Garden Grove, CA.

National Research Council. (1996). *National Science Education Standards.* Washington, DC: National Academy Press.

O'Neill, D. K., Wagner, R., & Gomez, L. M. (1996). Online Mentors: Experimenting in science class. *Educational Leadership*, *54*(3), 39-42.

Orion, N., & Hofstein, A. (1994). Factors that influence learning during a scientific field trip in a natural environment. *Journal of Research in Science Teaching*, *31*, 1097-1119.

Rennie, L. J., & Johnston, D. J. (2007). Research on learning from museum. In J. H. Falk, L. D. Dierking & S. Foutz (Eds.), *In principle, in practice*: *Museums* *as learning institutions* (pp. 57-73). Walnut Creek, CA: Alta Mira Press.

Rennie, L. J. (2007). Learning science outside of school. In S. K. Abell & N. G. Lederman, (Eds.), *Handbook of research in science education* (pp. 125-167). Mahwah, NJ: Lawrence Erlbaum.

Rennie, L. J., & McClafferty, T. P. (1995). Using visits to interactive science and technology centres, museums, aquaria and zoos to promote learning in science. *Journal of Science Teacher Education*, *6*, 175-185.

Rennie, L. J., & McClafferty, T. P. (1996). Science centres and science learning. *Studies in Science Education*, *27*, 53-98.

Roth, W. M. (1995). Knowing and interacting: A study of culture, practices and resources in a grade 8 open-inquiry science classroom guided by a cognitive apprenticeship metaphor. *Cognition and Instruction*, *13*, 73-128.

Scanlon, E., Jones, A., & Waycott, J. (2005). Mobile technologies: Prospects for their use in learning in informal science settings. *Journal of Interactive Media in Education*, *25*, 1-17.

Spier-Dance, L., Mayer-Smith, J., Dance, N., & Khan, S. (2005). The role of student generated analogies in promoting conceptual understanding for undergraduate chemistry students. *Research in Science and Technological Education*, *23*, 163-178.

Tal, R. T. (2012). Out-of-school: Learning experiences, teaching and students' learning. In B. J. Fraser, K. G. Tobin & C. J. McRobbie (Eds.), *Second international handbook of science education* (vol. 2, pp. 1109-1122). Dordrecht, The Netherlands: Springer.

Tabachneck-Schijf, H. J. M., & Simon, H. A. (1998). One person, multiple representations: An analysis of a simple realistic multiple representation learning task. In M. W. V. Someren, P. Reimann, H. P. A. Boshuizen & T. deJong (Eds.), *Learning with multiple representations* (pp. 197-236). New York, NY: Pergamon.

Tal, R. T., & Steiner, L. (2006). Patterns of teacher-museum staff relationships: School visits to the educational center of a science museum. *Canadian Journal of Science, Mathematics and Technology Education*, *6*, 25-46.

Thesen, L. (2001). Modes, literacies and power: A university case study. *Language and Education*, *15*(1/2), 132-145.

Tofield, S., Coll, R. K., Vyle, B., & Bolstad, R. (2003). Zoos as a source of free choice learning. *Research in Science and Technological Education*, *21*(1), 67-99

Van Meter, P. (2001). Drawing construction as a strategy for learning from text. *Journal of Educational Psychology*, *69*, 129-140.

Van Meter, P., & Garner, J. (2005). The promise and practice of learner-generated drawing: Literature review and synthesis. *Educational Psychology Review*, *17*, 285-325.

Varelas, M., & Pappas, C. C. (2006). Intertextuality in read-aloud of integrated science-literacy units in urban primary classrooms: Opportunities for the development of thought and language. *Cognition and Instruction*, *24*, 211-259.

Wertsch, J. V. (1991). *Voices of the mind*. Cambridge, MA: Harvard University Press.

Willett, R. (2007). Technology, pedagogy and digital production: A case study of children learning new media skills. *Learning*, *Media and Technology*, *32*, 167-181.