Association for Information Systems
AIS Electronic Library (AISeL)

2017 Proceedings of SIG GREEN Workshop

Winter 2-8-2018

Green Information Systems: Building Competences in Students

Carolyn McGibbon
University of Cape Town, carolynmcgibbon@gmail.com

Jacques Ophoff
University of Cape Town, jacques.ophoff@uct.ac.za

Green Information Systems: Building Competences in Students

Carolyn McGibbon
University of Cape Town
CarolynMcGibbon@gmail.com

Jacques Ophoff
University of Cape Town
Jacques.Ophoff@uct.ac.za

Abstract

The purpose of this study was to respond to a call to the Information Systems discipline to provide solutions to address global challenges such as the seventh Millennium Development Goal of ensuring an interconnectedness of society and the environment. A longitudinal study was conducted at the University of Cape Town (UCT) Information Systems Department where computer science students were tasked with conducting the campus carbon footprint as part of a Green Information Systems (Green IS) project. Drawing on Design Science Research two kernel theories were employed, namely Butler's model of Green Information Systems and Scharmer's Theory U. The goal of a broader study was to design a model for integrating Green IS into the curriculum. During the study 183 students evaluated the development of the Green IS course over a period of six years. In addition, four experts conducted summative evaluations at the conclusion of the study. Contributions are provided by developing a range of propositions related to emerging Green IS competences, including interpersonal, normative, anticipatory, and systems thinking competences.

Keywords

Green Information Systems, Sustainability Competences.

Introduction

Academics in the Information Systems (IS) discipline have made numerous calls for researchers to provide solutions to society's urgent challenges such as sustainability (Seidel et al. 2017; vom Brocke et al. 2015). This study is a response to the call. The paper also responds to a challenge to the IS discipline to make a better world (Walsham 2012) and address global challenges. One such challenge is the seventh Millennium Development Goal of ensuring an interconnectedness of society and the environment (Hajer et al. 2015).

Green IS defined as ''information systems employed to transform organizations and society into more sustainable entities'' (Carberry et al. 2017, p. 2), has emerged over the last decade as an important response from the IS community to the issue of sustainability (Malhotra et al. 2013).

Although the IS discipline is constantly updating its curricula to Higher Education students in order to ensure that graduates are aligned with the needs of the workplace and broader society (Topi et al. 2010), a focus on Green IS in the curriculum is conspicuous by its absence (McGibbon and Van Belle 2015).

Integrating sustainability into the curriculum is a relevant and persistent problem (Stough et al. 2018), with many academic disciplines recognizing that sustainability is one of the greatest challenges of our time and thus needs to be included in curricula (Sterling and Huckle 2014) with Information Systems needed to fill the gap (Elliot and Lavarack 2012). Literature reviews reveal a shortage of research into sustainability in Higher Education in Africa and, consequently, this research study is aimed at helping to meet this need.

Given the relevance of the topic, the researcher explored this key question: During an introduction to Green Information Systems what competences can be developed in students?

This paper is constructed as follows. It begins with a search through the relevant literature of Green IS as well as sustainability in Higher Education extant knowledge. The research method is elaborated and findings from the empirical data analyzed. Finally, conclusions are drawn with suggestions for further research.

Relevant Literature

The study examined a broad range of scholarly work as a way of examining the extant literature in the field of Green Information Systems. As the field was nascent the review included IS conference papers, book chapters, and theses. A proxy for scholarly articles was the use of Google Scholar with the Key words "Green + Information + Systems", netting a total of 622 articles from 2007 until the end of 2016. Figure 1 shows the growth of publications over this period.

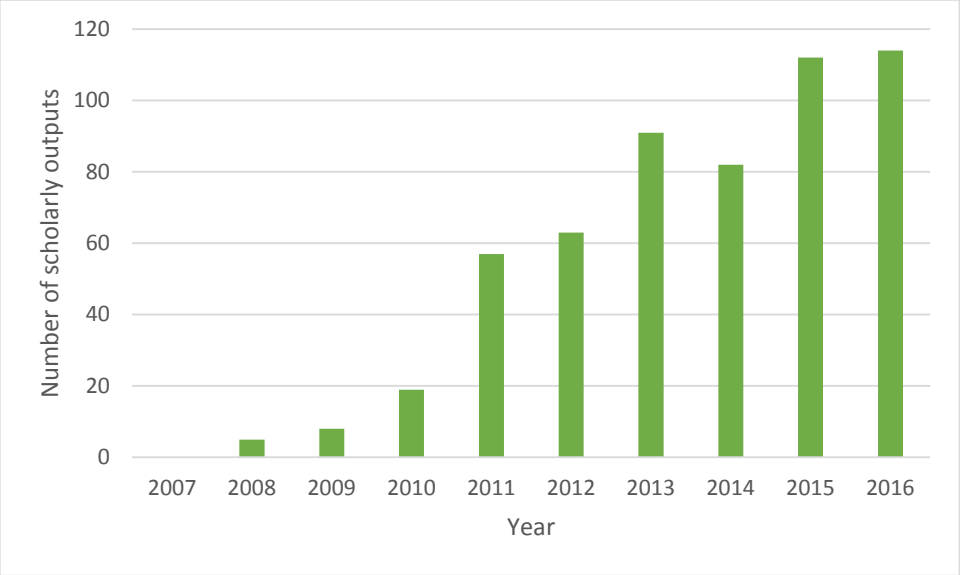

Figure 1: Growth of scholarly articles in Green IS.

The evolution of the scholarly tradition in Green IS may be categorized by the following four elements in a spectrum: starting with *conceptualization*, then *analysis*, leading to *design*, and lastly *impact* (Gholami et al. 2016; Malhotra et al. 2013). Research devoted to the latter phases of design and impact have led to fewer publications in Basket of Eight journals, (Corbett 2013; Loock et al. 2013). The end of the spectrum is thus seen as a research gap which is partly addressed in this study. The field of Green IS has led to a large amount of theorizing. To undergird the DSR project, the researchers identified Butler's 2011 model for Green IS, as a kernel theory, as it attempts to explain the drivers, activities and outcomes in a comprehensive way. This is backed by senior scholars who argue that most Green IS research fails to measure environmental impacts, but instead studies traditional IS issues such as organizational performance (Elliot and Webster 2017). However, a potential limitation of the Butler model is that it gives undue prominence to institutional theory (Carberry et al. 2015).

In terms of IS curriculum development, it must be noted that some scholars point to the reticence of academics in the discipline to embrace curriculum change. For example, Wayman and Kyobe (2012) argue that although continuous review of curricula is crucial, there are several reasons for resistance to change. These reasons include the need for a better understanding of the purpose for integrating relevant issues, perceptions of academics and learners amongst other issues. Their study showed that curriculum development in South African universities was heavily influenced by the department policies, possibly due to the historic development of the departments, which were often based on United States models with little African contextualisation (Wayman and Kyobe 2012).

From an educational perspective, the review ranged from software development models (for example, Cockburn, 2002), the theory of coherent practice (Scott 2012), to soft-skills development such as six hat thinking skills (De Bono 1990). Ultimately, during the course of the study, the researchers decided to adopt Theory U (Scharmer 2009) as a second kernel theory to inform the DSR, as it had been empirically tested in circumstances where problems were unstructured and not easily solved. This was seen as a good fit for Green IS problems which are not well defined and hard to solve. New solutions require a new personal awareness, as suggested by the Theory U (Senge et al, 2004).

In addition, a number of authors, including Wiek et al. (2015) have identified competences needed by students in Higher Education as part of their sustainability education. These include *systems thinking, and anticipatory, normative,* and *interpersonal competences.*

Systems-thinking competence is the ability to analyze complex systems on a broad scale by considering structures, patterns, feedback loops and other systemic features (Wiek et al. 2011). Anticipatory competence or "futures thinking" is the ability to anticipate how sustainability issues may evolve over time (Wiek et al. 2015, p. 244), whereas normative competence is the ability to assess the unsustainability of current and future systems (Silvius and Schipper 2014). *Interpersonal competence* is the ability to motivate, enable and facilitate collaborative work. It is defined as: "Graduates with interpersonal competence are able to initiate, facilitate and support different types of collaboration, including teamwork and stakeholder engagement, in sustainability efforts ... They are able to incorporate and complement the experiences and expertise of others when working in or leading teams in professional settings; in addition, they are able to successfully collaborate with various stakeholders from government, business and civil society. In these functions, graduates are skillful in communication, pluralist (trans-cultural) and empathetic understanding, deliberation, negotiation and leadership" (Wiek et al. 2015, p. 250).

Several constructs perceived to be useful for the evaluation of the Green IS project were identified in the literature. One of these was the concept of *socio-ecological integrity* which is based on human judgment and has been described as an integration of both human and natural systems (Fluker 2010; Luederitz et al. 2016). Another construct is the notion of *intra- and intergenerational equity*. These are derived from economics where it was argued that planetary resources are not inexhaustible and current generations need to consider the needs of future generations (Solow 1974). Intra-generational equity refers to social transformation issues within the existing generation (Mattioli 2013). A further construct is labelled *sequence of actions*, which implies defining goals, evaluating against criteria and devising evidence-led recommendations (Luederitz et al. 2016). *Sound methodology* takes this construct a step further to include problem analysis, visioning, assessment, monitoring and evaluation (Ceschin 2014). *Reflexivity and Learning* within the sustainability context refer to iterative analysis of the components, process and actors involved in the intervention as well as reflecting on the institutional context, enabling the generation of different outputs (Luederitz et al. 2016).

Methodology

A longitudinal six-year case study approach was employed, using the University of Cape Town as an exemplar and integrating sustainability into the project management course, with students required to measure an aspect of the campus carbon footprint. Drawing on Design Science Research (Gregor and Hevner 2013), the researchers used kernel theories, namely Butler's model of Green Information Systems (2012) and the change management framework Theory U (Scharmer and Kaufer 2013) to inform the design.

The goal of the curriculum intervention was to evaluate outputs that developed key sustainability competences. The ultimate intention was to create a real impact of a reduced Carbon Footprint at UCT, despite the current absence of regulatory or legislative pressure. This study forms part of a larger case study where the artifact developed is a model for incorporating Problem-based and Project-based sustainability learning in the Information Systems undergraduate curriculum. Each year between 22 and 39 students were involved in interventions over six iterations.

Key principles were drawn from international best practice, including how to address wicked sustainability problems, adopting a focus on developing sustainability solution options and key competences in sustainabilities (Brundiers and Wiek 2013; Luederitz et al. 2016; Wiek et al. 2015).

Formative evaluations were conducted at the end of each cycle of the design development. Archival evidence as well as student reflective essays were employed and content analysis and coding of the empirical data was conducted using ATLAS.ti, a data analysis software tool. r experts were invited to conduct evaluations and their questionnaires were coded and tested for co-occurrences.

Findings

The study yielded a total of 227 relevant observations which formed the basis of the empirical analysis. The evaluation criteria are mapped against the output competences as shown in Table 1 below. This shows that the strongest feature is normative competence (74 instances), and interpersonal competence (73 occurrences). This is followed by anticipatory competence (63 observations); and systems thinking competence (17 instances). Of interest is the co-occurrences between the evaluation criteria in the rows and the output competences in the columns according to the analysis conducted on Atlas.ti. This shows that the greatest number of linkages is between normative competence and collaboration. The lowest number of linkages is shown by the support criterion, indicating that this was not well developed in the process.

Evaluation criteria		Outputs: Competences		
	Anticipatory	Interpersonal	Normative	Systems Thinking
Anticipatory competence	0	12	15	4
Awareness	11	14	9	2
Collaboration	3	1	24	0
Equity	3	6	1	0
Expertise	3	5	2	0
Integrity	3	1	2	4
Interpersonal competence	12	0	12	4
Method	1	3	1	0
Normative competence	15	12	0	2
Reflexivity and learning	7	12	5	1
Sequence	1	3	1	0
Support	0	0	0	0
Systems Thinking	4	4	2	0
Totals	63	73	74	17

Table 1: Co-occurrences table showing linkages between constructs

Linkages between competences and other constructs were mapped on a radial diagram, shown in Figure 2.

In terms of the outcomes, two constructs were evaluated by the evaluators. They were socio-ecological integrity as well as intra- and intergenerational equity. These constructs were found to be weakly exhibited, according to the evaluators. Process issues were also discussed, with evaluators giving relatively high scores to constructs that included a sequence of actions, sound methodology, collaboration, and reflexivity and learning.

Finally, a range of inputs was evaluated, including awareness, expertise and support. Although awareness and expertise were identified during the evaluation, a shortage of institutional support was noted by evaluators.

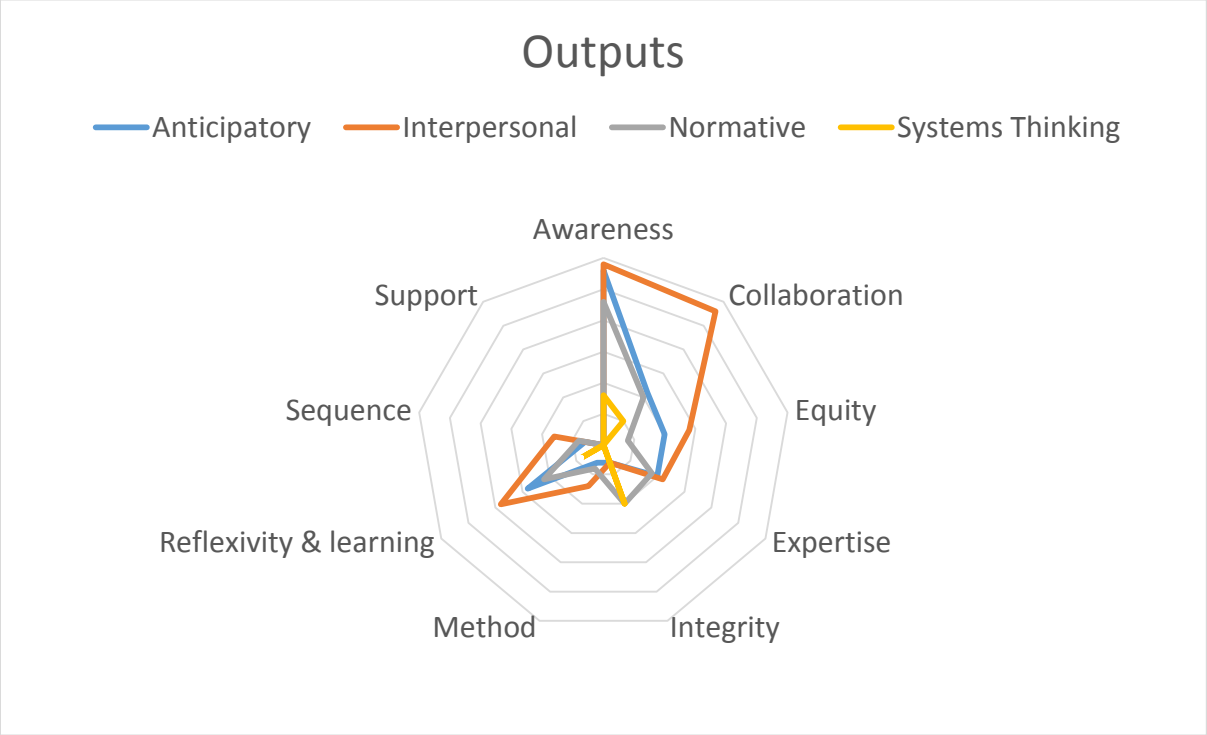

Figure 2: Linkages between competences and other constructs.

Discussion

Four propositions were derived from the empirical analysis and corroborated in the literature and discussed in this section.

P1: *When students develop interpersonal competences during Green IS education, reflexivity and learning processes are enhanced.*

This is corroborated in the literature as it aligns with research into Problem-based and Project-based Learning (PPBL) courses in sustainability (Brundiers and Wiek 2013b; McGibbon and Van Belle 2015). PPBL is a learner-centered approach that empowers students to conduct research, integrate theory and practice, and develop feasible solutions to specific problems (Savery 2006). This is supported by the Information Systems undergraduate curricular guidelines, as the IS2010 version states that students need to develop interpersonal skills, such as problem solving in a team (Topi et al. 2010). Competencies have been defined as both "basic" competencies, such as interpersonal skills, as well as strategic and systems thinking competencies (Wiek et al. 2011). The latter competency is ideally suited to the IS curriculum, which encourages students to see the interconnectedness of people, technology, data and processes as a dynamic system. A global study found that assessed PPBL courses showed compliance with key principles, including addressing wicked sustainability problems, adopting a focus on developing sustainability solution options, and developing teamwork, as well as stakeholder collaboration (Brundiers and Wiek 2013). Furthermore, the promotion of social and institutional learning for sustainable development has been identified as one of the key research themes predicted for the next decade (Miller et al. 2014).

The data suggest a further proposition:

P2: *When students develop interpersonal competences during Green IS education there is a tendency to develop normative and anticipatory competences.*

This has some backing in the literature. An example of this in PPBL is where students engage in real-world sustainability problems and attempt to find solutions. Key principles underlying PPBL courses include addressing sustainability problems, focusing on solutions and recognizing the need for teamwork and stakeholder collaboration (Brundiers and Wiek 2013a).

The data also show strong links between normative competence (to collectively assess the unsustainability of current campus operations and make recommendations on how to make UCT more sustainable) as well as anticipatory competence (the ability to visualize the future, related to sustainability issues). This suggests the following proposition:

P3: *When students develop normative competence during Green IS education their ability to develop anticipatory competence is increased.*

This has resonance in the literature. Normative competence and anticipatory competence are complementary and both incorporate an understanding of current unsustainability as well as the ability to envisage future scenarios (Wals and Corcoran 2006). This is supported by (Adomssent et al. 2007)who define sustainability competence as the ability to shape future scenarios by active involvement in modelling and transforming society towards sustainable practices. Further support comes from authors who note that envisioning future scenarios and developing future-thinking skills amongst students inculcates commitment which leads to innovation and action strategies for change (Cebrián and Junyent 2015).

This suggests proposition four:

P4: *When students work collaboratively during Green IS education they are likely to develop interpersonal competence.*

There is some evidence for this in the literature. For example, Lozano argues that collaboration is key to sustainability "requiring that all the players, even the silent ones such as the environment and future generations of plants, animals and humans, communicate, become highly involved and learn from each others' experiences. Each of the players needs to keep an open mind to recognize that the other players, present and future, are different and behave differently, where their needs must be recognized, addressed and fulfilled" (Lozano 2007, p. 380).

Conclusions

This paper sought to find a way of developing a range of competences in students who were introduced to Green IS as part of a broader Design Science Research study. Normative competence was observed to be the strongest competence to emerge during the intervention, when students in Higher Education were introduced to Green IS. This implies that the students had developed the ability to assess the university's future and current systems. The next strongest competence was interpersonal competence (the ability to foster and enable collaborative work in their teams) followed by anticipatory competence, meaning the ability to envision the future. These four key competences were strongly linked to reflexivity and learning. Future researchers could test the competences via different paradigms, such as positivist and interpretivist studies. Testing of the propositions could deepen understanding of the topic.

This research project thus provides a seam of rich possibilities for further quantitative and qualitative research as envisaged by global Green IS experts (Seidel et al. 2017).

REFERENCES

Adomssent, M., Godemann, J., Michelsen, G., Barth, M., Godemann, J., Rieckmann, M., and Stoltenberg, U. 2007. "Developing Key Competencies for Sustainable Development in Higher Education," *International Journal of Sustainability in Higher Education* (8:4), pp. 416-430.

Brundiers, K., and Wiek, A. 2013. "Do We Teach What We Preach? An International Comparison of Problem- and Project-Based Learning Courses in Sustainability," *Sustainability* (5:4), pp. 1725-1746.

Carberry, E., Bharati, P., Levy, D. L., and Chaudhury, A. 2015. "Institutional Fields and Green Is: Understanding the Influence," *SIG Green*: Sprouts Proceedings.

Carberry, E. J., Bharati, P., Levy, D. L., and Chaudhury, A. 2017. "Social Movements as Catalysts for Corporate Social Innovation: Environmental Activism and the Adoption of Green Information Systems," *Business & Society*).

Cebrián, G., and Junyent, M. 2015. "Competencies in Education for Sustainable Development: Exploring the Student Teachers' Views," *Sustainability* (7:3), pp. 2768-2786.

Ceschin, F. 2014. "How the Design of Socio-Technical Experiments Can Enable Radical Changes for Sustainability," *International Journal of Design* (8:3).

Corbett, J. 2013. "Designing and Using Carbon Management Systems to Promote Ecologically Responsible Behaviors," *Journal of the Association for Information Systems* (14:7), p. 339.

De Bono, E. 1990. *Six Thinking Hats*. London: Penguin.

Elliot, S., and Lavarack, J. 2012. "Is-Enabled Innovation to Overcome Resistance and Improve Contributions to Sustainability by Universities: An Is Research Agenda," *PACIS*, p. 15.

Elliot, S., and Webster, J. 2017. "Editorial: Special Issue on Empirical Research on Information Systems Addressing the Challenges of Environmental Sustainability: An Imperative for Urgent Action," *Information Systems Journal* (27:4), pp. 367-378.

Fluker, S. 2010. "Ecological Integrity in Canada's National Parks: The False Promise of the Law," *Windsor Rev. Legal & Soc. Issues* (29), p. 89.

Gholami, R., Watson, R. T., Hasan, H., Molla, A., and Bjørn-Andersen, N. 2016. "Information Systems Solutions for Environmental Sustainability: How Can We Do More?," *Journal of the Association for Information Systems* (17:8), p. 2.

Gregor, S., and Hevner, A. R. 2013. "Positioning and Presenting Design Science Research for Maximum Impact," *MIS quarterly* (37:2), pp. 337-355.

Hajer, M., Nilsson, M., Raworth, K., Bakker, P., Berkhout, F., de Boer, Y., Rockström, J., Ludwig, K., and Kok, M. 2015. "Beyond Cockpit-Ism: Four Insights to Enhance the Transformative Potential of the Sustainable Development Goals," *Sustainability* (7:2), pp. 1651-1660.

Loock, C.-M., Staake, T., and Thiesse, F. 2013. "Motivating Energy-Efficient Behavior with Green Is: An Investigation of Goal Setting and the Role of Defaults," *Mis Quarterly* (37:4), pp. 1313-1332.

Lozano, R. 2007. "Collaboration as a Pathway for Sustainability," *Sustainable Development* (15:6), pp. 370-381.

Luederitz, C., Schäpke, N., Wiek, A., Lang, D. J., Bergmann, M., Bos, J. J., Burch, S., Davies, A., Evans, J., and König, A. 2016. "Learning through Evaluation–a Tentative Evaluative Scheme for Sustainability Transition Experiments," *Journal of Cleaner Production*).

Malhotra, A., Melville, N. P., and Watson, R. T. 2013. "Spurring Impactful Research on Information Systems for Environmental Sustainability," *MIS Quarterly* (37:4), pp. 1265-1274.

Mattioli, G. 2013. "Car Dependence, Sustainability and the Transport Policy Stalemate: The Potential Trade-Offs between Intra-and Inter-Generational Equity," *The International Journal of Sustainability Policy and Practice* (8:1), pp. 45-57.

McGibbon, C., and Van Belle, J.-P. 2015. "Integrating Environmental Sustainability Issues into the Curriculum through Problem-Based and Project-Based Learning: A Case Study at the University of Cape Town," *Current Opinion in Environmental Sustainability* (16), pp. 81-88.

Miller, T. R., Wiek, A., Sarewitz, D., Robinson, J., Olsson, L., Kriebel, D., and Loorbach, D. 2014. "The Future of Sustainability Science: A Solutions-Oriented Research Agenda," *Sustainability Science* (9:2), pp. 239-246.

Savery, J. R. 2006. "Overview of Problem-Based Learning: Definitions and Distinctions," *Interdisciplinary Journal of Problem-Based Learning* (1:1).

Scharmer, C. O. 2009. *Theory U*. San Francisco: Berrett-Koehler.

Scharmer, C. O., and Kaufer, K. 2013. *Leading from the Emerging Future: From Ego-System to Eco-System Economies*. Oakland: Berrett-Koehler

Scott, E. 2012. "Towards Coherent Practice in Capstone Courses for Is Majors," in: *Information Systems*. University of Cape Town.

Seidel, S., Bharati, P., Fridgen, G., Watson, R. T., Albizri, A., Boudreau, M., Butler, T., Kruse, L. C., Guzman, I., and Karsten, H. 2017. "The Sustainability Imperative in Information Systems Research," *Communications of the Association for Information Systems* (40:1), p. 3.

Silvius, A. G., and Schipper, R. P. 2014. "Sustainability in Project Management Competencies: Analyzing the Competence Gap of Project Managers," *Journal of Human Resource and Sustainability Studies* (2:02), p. 40.

Solow, R. M. 1974. "Intergenerational Equity and Exhaustible Resources," *The review of economic studies* (41), pp. 29-45.

Sterling, S., and Huckle, J. 2014. *Education for Sustainability*. Routledge.

Stough, T., Ceulemans, K., Lambrechts, W., and Cappuyns, V. 2018. "Assessing Sustainability in Higher Education Curricula: A Critical Reflection on Validity Issues," *Journal of Cleaner Production* (172), pp. 4456-4466.

Topi, Valacich, J. S., Wright, R. T., Kaiser, K., Nunamaker Jr, J. F., Sipior, J. C., and de Vreede, G.-J. 2010. "Is 2010: Curriculum Guidelines for Undergraduate Degree Programs in Information Systems," *Communications of the Association for Information Systems* (26:1), p. 18.

vom Brocke, J., Heddier, M., and Seidel, S. 2015. "In Search of Information Systems (Grand) Challenges," *Business & Information Systems Engineering*), pp. 1-14.

Wals, A. E., and Corcoran, P. B. 2006. "Sustainability as an Outcome of Transformative Learning," *Drivers and barriers for implementing sustainable development in higher education*), p. 103.

Walsham, G. 2012. "Are We Making a Better World with Icts&Quest; Reflections on a Future Agenda for the Is Field," *Journal of Information Technology* (27:2), pp. 87-93.

Wayman, I., and Kyobe, M. 2012. "Incorporating Knowledge of Legal and Ethical Aspects into Computing Curricula of South African Universities," *Journal of Information Technology Education* (11), pp. 139-157.

Wiek, A., Bernstein, M., Foley, R., Cohen, M., Forrest, N., Kuzdas, C., Kay, B., and Keeler, L. 2015. "Operationalising Competencies in Higher Education for Sustainable Development," *Handbook of Higher Education for Sustainable Development, Routledge, London*), pp. 241-260.

Wiek, A., Withycombe, L., and Redman, C. L. 2011. "Key Competencies in Sustainability: A Reference Framework for Academic Program Development," *Sustainability Science* (6:2), pp. 203-218.