Implementation of Transformative Sustainability Learning into Engineering Curricular

Yuliana Lavrysh

PhD, Associate Professor, National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute"
(Kyiv, Ukraine)
E-mail: yulavrysh@gmail.com
ORCID: 0000-0001-7713-120X

Nowadays an engineering profession is the most promising in terms of sustainability. Yet, there is a question if higher educational establishments are ready and possess necessary resources to prepare graduates in a sufficient way to create a life-sustainable future. Therefore, universities recognize the education for sustainable development as an essential and timely process of engineering training. The paper presents the characteristics of transformative sustainability learning as a key factor of advanced life-learning engineering education. The analysis of theoretical background signifies that the transformative sustainability learning concept is based on the theory of person's transformations depending on such personality traits as the life experience, cognitive development, and critical reflection skills which foster personality changes towards sustainability. Thus, we can state that transformative sustainability learning (TSL) integrates such fields as transformative learning and Education for Sustainable Development and the combination impacts personal and societal transformations. This fact provides us with the opportunity to suggest the (TSL) concepts implementation into engineering educational process as an approach that enhances students' motivation to studying, understanding of sustainability issues and high order thinking skills. If students experience personality transformations, we can find out the pedagogical strategy attributed to these transformations. Having conducted interviews and observations the teaching process at the university, we outlined the most used TSL pedagogical strategies at technical university (placed-based, problem-based, enquiry and service learning) assessed their efficacy, found out the barriers to successful implementation and suggested recommendations to overcome the barriers. Our paper demonstrates potential of TSL implementation as it not only benefits for students but also enhances sustainability-related pedagogies transformative power.

Keywords: transformative learning, educational for sustainable development, placed-based learning, community service learning, problem-based learning, enquiry learning

Received November 18, 2017; accepted March 1, 2018

Future Human Image, Volume 9, 2018:
DOI: 10.29202/fhi/9/6

Introduction

The key terms, which describe the current processes in the education, are transformations and sustainability. The greatest challenge of the 21-st century is the issue of mind and nature integration in order to provide our future generations with sustainable living conditions. A new recognition of sustainability problems requires urgent solutions, which are not only technical or political but educational as well. Thus, only due to educational means it is possible to change thinking and cognition mode towards sustainability.

As it is stated in UNESCO (2010) Global Action Program on Education for Sustainable Development (ESD), the international acknowledgment of ESD as an essential part of a quality education is a priority for the modern system of education. ESD objective is to create more sustainable and viable society by changing the way of our thinking about the world we live in. The foremost characteristics of ESD are interdisciplinary, collaboration and transformation. Such background implies the involvement of full spectrum of educational establishments for all professions from colleges to doctoral departments at universities.

The World Federation of Engineering Organizations (WFEO) supports the ideas of sustainable development within the engineering education as engineers are qualified with relevant technical skills and knowledge. Thus, the objective of engineering education is to enhance graduate's competencies in combining scientific innovations and business undertakings. Therefore, higher engineering education should be aimed at sustainable development and further environmentally mindful outlook, as well as a sense of ethical liability with a view to the training of decision-makers, leaders, and researchers. It is obvious that the valuable outcomes of ESD can be achieved through reflection, dialogues, contemplation, and creativity.

It implies that universities are responsible for a shift from a traditional transition of skills and knowledge by teaching and researching towards social needs as well as by generating new educational concepts such as student-centered, cooperative and transformative learning. It is not enough to change curriculum content, sustainable education demands greater changes. Transformative learning and pedagogy can provide the extent of changes regarding the development of analytical, context-related, interdisciplinary, holistic and reflective thinking skills in students. To integrate the ESD values and principles into higher education, we have to be aware of teaching approaches transformations which should be focused on the processes of learning and skills development rather than the knowledge presentation and accumulation.

Objective of the study

This paper is aimed at investigating how transformative sustainable learning strategies can emerge from an educational institution, students, and social interaction and enhance the students' academic achievements. The paper presents the discussion of higher engineering education transformation necessity and urgency towards sustainability challenges, which come from industry, future graduates and society as well. The transformation should involve not only changes in the content of a curricular but the paradigm of teaching and knowledge acquisition.

The overall objective of the paper is to study the teaching strategies of Transformative Sustainability Learning employed at Igor Sikorsky Kyiv Polytechnic Institute in order to evaluate their efficiency, to investigate the degree to which they contribute to transformative sustainability education, to discuss barriers to their implementation and suggest solutions.

Theoretical framework

The significance and role of sustainability in higher education have been a mainstream and a policy concern for last fifteen years. The circumstantial challenges of sustainability have attracted the attention of transformative learning scholar as a pedagogic strategy that provides transformations of individuals and communities with the aim to create a sustainable society.

The literature on sustainable education shows a variety of disputative studies searching for the best implementation ways for ESD. Notable professors Stephan Sterling and Ian Thomas indicated three main educational notions that universities are supposed to perceive in order to develop sustainable education: education about sustainability, education for sustainability and sustainable education [Sterling & Thomas, 2006]. The scientists explain that education about sustainability is the representation of factual information; education in sustainability implies experimental and practical approaches to acquire new skills and knowledge; education for sustainability is focused on personal transformations when students adopt sustainability values and principles into their lives. The move toward sustainable education is a challenge for universities as it implies the combination of social, economic and environmental issues study and considering behavioral students' changes as well.

Regarding the Engineering Department curricula content in the frame of sustainability, Association for the Advancement of Sustainability in Higher Education (2010) suggests that the basic courses for sustainable education should be Engineering, Materials Science, Environmental Science and English. It is explained by the fact that, Engineering and Materials Science deal with industrial processes, connected with consumption and production, while Language learning impacts students' emotional perception of environmental realities in a critical way through fiction and non-fiction eco-literature and ecocompositions.

With a view to enforcing the education for sustainability in universities, Barbara de la Harpe and Ian Thomas suggested teaching approaches that will contribute to the development of such student's skills like team work, problem-solving and multidisciplinary thinking [De la Harpe & Thomas, 2009]. They identified three main approaches the personal, re-connecting to reality and holistic thinking. The personal approach means teachers' acting as role models for learners; re-connecting to real life situations implies real-life experience, enacting social changes and connecting with people and nature; and holistic thinking involves critical thinking development.

Well-known transformational learning theorist Jack Mezirow [Mezirow, 2011] explained the transformative learning as a theory of comprehension and experience altering. He considers the transformation as a natural phase of the personal development, which occurs, while every transition from one educational level to the other: from school to college, from university to working career. Meaningful shifts evolve in response to life experience, especially if it induces powerful emotional responses in the individual. The objective of transformative learning is to revise old assumptions and ways of interpreting experience through critical reflection and self-reflection. It means to empower individuals to change their perspectives and habit of minds (understanding of what is "right" or "wrong").

Professional challenges, non-compliance with knowledge level and volume, interruption in professional career or promotion provide a starting point for transformative processes. Engineers realize their objectives and seek ways of their possible achievement that can complicate educational activities. Conscious altering enhances and accelerates self-actualization process

[Hussey, 2010]. Thus, one of the transformative learning targets is to shift the control focus from the external environment into internal which ensures the awareness of own capabilities, enriches and masters professional skills. This idea is supported by Stephan Sterling who claims that transformative learning touches deeper levels of meaning which impact our immediate level of perception [Sterling, 2006]. According to the finding of mentioned above transformation theorists, the perceptual changes and following shifts to a more rational and ethical way of worldview inspire the emergence of new ideas and values.

Concerning Transformative Sustainability Learning (TSL), scholars Yona Sipos, Bryce Battisti, and Kurt Grimm outline transformative changes corresponding to cognitive, psychomotor and affective domains of learning [Sipos et al., 2008]. TSL combines sustainability and transformative learning in order to contribute to profound personal and societal changes which are reflected in upgraded skills, knowledge and attitude towards ecological, social and economic justice. This connection allows speaking about TSL as a separate pedagogical strategy, which employs transdisciplinary, experiential, and placed-based learning.

Due to the multidimensional and complex nature of sustainability, it would be beneficial if TSL were introduced by main ESD-related pedagogical strategies, defined by UNESCO [UNESCO, 2012]: discovery learning, transmissive learning, collaborative, problem-based, interdisciplinary learning, multi-stakeholder social learning, and critical thinking-based learning. Taking into account the variety of strategies, Yona Sipos, Bruce Battisti, and Kurt Grimm tried to match sustainability pedagogical strategies with learning domains [Sipos et al., 2008]. Thus, they suggest that problem-based learning, critical emancipator pedagogy and pedagogy for ecological justice should correspond to the development of cognitive domain; experiential, applied learning, action learning and research in combination with service learning facilitate psychomotor domain development; environmental and placed — based learning influence affective domain. By this division scholar offer the distinguishing of learning objectives as well:

a) Cognitive domain: critical, reflective, systemic thinking, understanding of sustainability and global citizenship issues;
b) Psychomotor domain: employment of acquired knowledge to engage in activities to solve problems local community might have;
c) Affective domain: formation of value-focused inclusive thinking, encouraging students to wish to form a meaningful collaboration with a view to creating better and more appealing alternatives for making sustainable solutions.

Noted scholars Marcus Jean, Nicolas Coops, Ellis Shona, and John Robinson have also arrived at conclusion that TSL strategies implementation efficiency depends on transformational changes in cognitive, psychomotor and affective domains [Jean et al., 2015]. They proposed such key points for TSL implementation:

a) Engaging a cognitive domain through academic learning, lectures, workshops, seminars, and so forth;
b) Engaging psychomotor domain through applying theoretical knowledge to solve practical problems such as designing, inventing, testing, building, and so forth;
c) Engaging affective domains through behavioral changes which are the main goal of TSL.

This approach provides us with evidence about the quality of conducted learning as we can see whether sustainability has just “been learned” regarding cognitive domain or it has been practiced and experienced with following transformational results.

Scholars form Luxembourg University highlight that the objective of transformative sustainability science is to study and investigate the process of society, enterprise, educational establishment, and government collaboration focused on transformation of human and environment relationships [König, 2015; Dyball & Davila, 2016]. Therefore, the research approach implies the combination of disciplines, knowledge, and skills: solution-oriented thinking skills from natural sciences and professional courses, knowledge of society functioning, cultural tolerance and communication skills from social sciences and humanities. By integration of concepts and skills, transformative learning can emerge as a social learning process rather than a science or discipline

Thus, we can state that TSL approach contributes to the involvement of learners to employ principles, values, and goals of sustainability aimed at societal transformations. The TSL in combination with sustainability pedagogies is powerful tool to plan, assess and reflect on the efficiency of transformations.

Research design and implementation

Sustainable pedagogies, as well as TSL implementation, depend on teachers' experience, motivation, comprehension of issues, and self-development abilities. This process requires courage to accept the challenge and implement new strategies. Thus, in order to apprehend teachers' experience and opinion about TSL and sustainability pedagogies adaptation and implementation, we have designed a qualitative survey involving semi-structured interviews, questionnaires and a workshop with the following discussion. The combination of these research methods ensured the most accurate interpretability of the data. Moreover, 10 semi-structured interviews and discussions of questionnaire about strategies gave us a wonderful opportunity to set an efficient interaction between participants. After the interviews, we conducted a workshop on TSL pedagogical strategies with the following discussion.

We surveyed on the basis of three faculties: Linguistics, Mechanical Engineering, and Environmental Engineering. The choice of the audience is explained by the range of classes and methods employed at the Faculties; a number of teachers involved in university sustainability programs and courses; interdisciplinary connections which are rather tight among teachers of these faculties as we are often engaged in transdisciplinary projects.

One of the goals of this research was to find out what sustainability pedagogies are used at the university and the level of their relevance to TSL. Taking into account our personal experience and finding of numerous studies, it is obvious that there is no single strategy that is employed for all subjects or for achieving learning outcomes. Teachers of our university apply a lot of educational traditional and alternative methods. To disclose the most applied methods, we provided participants with the list of twelve pedagogical strategies and the task was to point out the most used strategies during the learning process.

Another method of data collection in this study was a performing of interviews. We prepared a list of questions for teachers:

1. How long have you been teaching the subject?
2. What pedagogical strategies do you mostly use? Why?
3. Which pedagogical strategies are the most rewarding for teachers and students?
4. In light of your teaching experience: what aspects of your teaching need mastering or improving?
5. What TSL strategies do you apply?

6. What TSL strategies would you like to apply?
7. What are main barriers, which prevent from TSL strategies implementation?
8. What pedagogical knowledge or skills do you lack?
9. What information about TSL strategies would you like to get regarding professional development?
10. Why do you want to implement TSL strategies?

In the process of the interviewing, all participants (30 teachers in total: 10 from the department) were ensured of the anonymity of their responses, then, after obtaining permission from the participants, the interview was recorded and interpreted immediately. The interviews lasted for 30-45 minutes on average, and each interview was conducted in one session.

The last our step was a workshop with the following discussion on TSL learning and its strategies. During the workshop we explained TSL learning foundations, principles and values; demonstrated TSL pedagogical strategies, explained their methodology and limitations; discussed questions outlined during interviews. All teachers were provided with necessary sources and teaching materials.

Results and discussion

The survey revealed the most applied pedagogical methods used by teachers at the university, requirements and barriers for TSL strategies implementation. It should be noted that all participated teachers use student-centered methods and consider that the learning process is the responsibility of teachers as well as students. It implies that teachers demonstrate a profound teaching background for successful TSL strategies implementation. However, not all of them have a pedagogical education, so they studied methodology and didactics while practicing classes. Thus, TSL is a great challenge for such teachers to start from the scratch and achieve good results. Although, it was a good opportunity to interact with students and motivate them to study together.

Having conducted the first step of our research (completing the questionnaire about strategies application), determining the percentage of strategies application, we received results, which are demonstrated in the Table 1:

Percentages of experienced strategies

Strategy	**Percentage**
Lectures	80%
Presentations	100%
Workshops and discussion	75%
Group work activities	50%
Experiential activities	50%
Simulations/role plays	50%
Problem-based pedagogy	40%
Placed-based learning	15%
Action learning	25%
Enquiry learning	10%
Community problem solving learning	10%

Interdisciplinary activities	25%

It is obvious from the results that traditional strategies (lectures, presentations, workshops, group work activities) are more widely used than TSL-related ones. Mostly lectures and presentation are used for introduction and presenting of the new educational material while workshops and discussions are for revising and mastering. However, according to a student-centered approach, teachers transform conventional lectures into interactive when students are free to ask, comment and doubt. Moreover, the role of a teacher completely differs from a teacher-centered approach, since a teacher should serve as a facilitator in the process of students knowledge acquiring.

On the other hand, such innovative strategies as placed-based, active and discovery learning are not often employed in classes. During the interviews, we asked teachers about these strategies and their attitude towards them. Most answers dealt with lack of knowledge and time to apply it. Teachers from Mechanical Engineering Faculty did not find the educational material, which can be taught in such way. Some teachers of language and environmental science have applied these strategies.

Placed-based learning is well suited for language education as it allows to speak about local, known for students problems promoting their engagement, so language classes become a platform for language skills acquiring as well as for discussions and finding solutions for local sustainability issues. This kind of learning provides students with knowledge that extends beyond the content of only engineering disciplines and content by employing authentic experience. The efficiency of this strategy rises in combination with the project-based learning, which is better suited for teaching engineering disciplines by taking as a background a locally relevant problem. For instance, teachers from Environmental Engineering courses suggested project about sustainability problems in students' locality with developing real engineering solutions. The feedback from students demonstrated their great involvement and motivation and the community obtained human resources for finding better solutions. As they commented: "At last we have found real employment to our theoretical knowledge and made our native towns more sustainable." After the project, during classes on English Language writing skills, students wrote project descriptions and reports, which were published in university students' newspaper.

The outcomes of our survey are fully confirmed by the findings of Brian Johnson, Michael Duffin, and Michael Murphy that placed-based learning joint with personalized learning models provide highly functioning democracy of informed, engaged citizens [Johnson et al., 2012]. This statement corresponds to main, goals of TSL to transform our students into involved and committed engineering leaders.

With mostly the same direction of educational goals and learning transformations, we outlined community serviced learning as a practical way of finding solutions to the local issues. Serviced learning involves experiential learning or practical activities which students are able to perform for the community. Due to service-learning students can connect personal, social and professional development. Community involvement usually occurs through cooperated projects between faculty and community representatives (non-governmental organizations, agencies) where course content is integrated into a real-world context. According to Kerissa Heffernan, service learning is considered as integrative, reflective, contextualized, reciprocal and lifelong educational strategy which outcomes are as follows: application of theory to practice, development of high order thinking skills, self-estimation rising through the

development of personal efficacy and identity, improvement of communication and leadership skills, advancement of social responsibility, deeper cultural and citizenship understanding [Heffernan, 2001]. Faculties also gain some positive feedback and benefits: interdisciplinary which leads to new research and ideas, improvement of students learning outcomes, a connection of curriculum with real-world requirements, increased the level of students motivation and commitment to study.

There are a lot of possibilities how to integrate this learning type into a classroom. We will share some of those conducted at the university: collecting of stories about regional traditions and cultural features with following presentations, writing letters to environment protecting and granting organizations (Faculty of Linguistics); collecting of local water and soil samples to provide environmental impact factor report with following recommendations and solutions (Environmental Engineering Faculty); developing of survey of the most sustainable technologies, which could be used locally (Mechanical Engineering Faculty).

Enquiry learning is crucial for the development of high order thinking skills, which are vital for engineers. The abilities to analyze, synthesize and reflect change students habits of world perception from a single-side approach to extending multi-sides critical view on the problem. Students are not afraid of mistakes, and wrong solutions and teachers do not punish for weak attempts as everyone understands the value of experiential way for the truth discovery. The main idea of the strategy is that students process the data and information they obtain during experiments or research and afterward reach their own conclusions [Hutchings, 2007]. Students are responsible for the outcomes, teachers just direct and watch. It requires teacher-student partnership, high academic achievements and a wide range of necessary skills.

The results of interviews demonstrated that teachers mostly use this strategy at lab-classes, during experiments for scientific research, and for project performance. In UNESCO source for "Teaching and Learning for Sustainable Future", we found suggested seven stages for this strategy implementation: tuning in, deciding directions; preparing to find out; finding out; sorting out; drawing conclusions; considering social action [UNESCO, 2010].

When we discussed this strategy and its steps during our workshops teachers confessed that it is difficult for them to believe in abilities, respect students' ideas and give students mostly unlimited freedom. Another point that was mentioned in terms of steps, that almost all steps are understandable and applied except the last one about the social outcome of an experiment. It is often neglected or under evaluated as it takes much time to get a feedback from the community. However, teachers agreed that it is a necessary point for implementation of TSL strategies and motivating students to learn when they see positive results of their work.

Another sustainability pedagogy, interdisciplinary project-based learning, is aimed at the problem rather than at the separate discipline at a time. It emphasizes more complex and expanded awareness of the topic. A range of information source from different disciplines, active engagement, and integration of necessary skills allow students to acquire innovative and unexpected results. Furthermore, when students apply a variety of skills and perspectives, they admit the sense and value of what they are studying. The nature of PBL resembles the character of sustainable development, which is also multidimensional and integrated. Due to the implementation of the strategy, students are able to define sustainable problems, develop controversial discussion, find supportive evidence, acquire and process necessary information from a variety of resources and create argument-based solutions.

While discussing with students a problem of sustainability, we determined a lack of

interdisciplinarity through curricula within the frame of sustainability. Many students knew about this issue for the first time only at English classes opposite to students from universities of Europe or the USA, where sustainability development has already penetrated all courses of mostly all departments regardless the context of the training program on humanities, art or engineering. We consider it as the main drawback of Ukrainian universities to suggest sustainability courses mostly for Master degree students.

However, a beneficial example of TSL implementation is an interdisciplinary project-based approach related to students' majors or future engineering carrier in terms of sustainability. It is worth mentioning that when students search for information relevant to their career, they are more motivated. For instance students were suggested topics for their choice: perform a sustainability audit for a campus, develop a plan for deconstruction of old university buildings or campus, develop programs for energy consumption reducing, develop green device or technology, develop and recycling and composting program for campus facilities, develop a sustainability Web site to coordinate and enhance students sustainability actions, provide guidelines for greening their future products manufacturing or tools design. At the beginning of a year, students were divided into groups for the project developing. Then students presented their projects to a jury of English teachers and major discipline teachers. The work on the project was performed by students themselves if they needed consultations teachers of major discipline organized such consultations. However, every English class students had to prepare a short report on actions, which had been done.

The present study confirms that TSL strategies motivate students to learn by setting them in situations where they feel as authors of changes and answers. However, while our interviews teachers admitted the presence of some barriers, which prevent successful implementation. Analyzing these barriers, we have to admit that these obstacles can be divided into two categories: originated from teacher's behavior, outlook, and those related to educational management, curricular design, time and resources limitations, and some students in classes. We have outlined main barriers admitted by almost all teachers:

a) A large volume of necessary educational materials defined in a curriculum and time shortage prevent from advanced strategies using;
b) Lack of motivation in students and teachers regarding innovations of a learning process;
c) Not enough time for professional pedagogical development due to overload by professional courses requirements;
d) Not enough evidence of suggested TSL strategies efficiency, lack of developed and approved methodology for teaching technical majors;
e) Not sufficient students' theoretical background necessary for effective strategies implementation.

However, as we could notice from the research results, the main barrier is lack of teachers' pedagogical knowledge and skills how to organize the educational process in the most efficient way. Unfortunately, most teachers from technology departments were not trained for teaching.

Having discussed these barriers with teachers, we understand that not all of them can be eliminated only by teachers themselves. However, if teachers demonstrate respect to students' background and intentions; provide open communication; display positive feedback; facilitate students' personal and professional growth, the implementation of advanced educational strategies will be effective for students and society as well. With this in mind, we would like to suggest some recommendations for improving the situation:

a) To include the requirements of advanced methods using into teachers' assessment rubrics and rating system;
b) To ensure that teachers efforts and intentions are in line with university educational objectives and policy;
c) To raise students' motivation by encouraging their attempts in searching of personal learning style and methods, respecting their ideas and results and building partnership;
d) To organize systemic and holistic interdisciplinary approach to curricular design;
e) To provide timely and systematic lessons planning and guiding;
f) To provide students with relevant, authentic and profession-related information.

Following some of these recommendations, we hope that teachers will see changes in their teaching practice. Because we consider that the key factor in teaching is meaningful interaction and collaboration between students and teachers rather than facts acquisition. Authentic methods, context and assessment of learning, which TSL belongs to, make the learning process more explicit and reflective.

Conclusions

In summary, it is necessary to admit that there are still many more problems in education to be solved in order to meet the requirements of the changing world. However, we would like to assume that engineering education is moving toward learning beyond the university. With time, the distinction between the postgraduate studying and life-long learning will disappear.

In our survey, we tried to demonstrate the TSL strategy as an effective and promising educational strategy Moreover, we consider TSL as not an only educational tool but a useful sustainability-oriented method with transformative potential, which facilitates sustainability exploration and perception. TSL possesses a great potential and is based on constant social shifts, which enable students to develop their professional skills and strategies, become conscious of prior assumptions, achieve critical reflection upon these assumptions, create an effective working process and become real leaders for creating sustainable future. Within this framework, we assume that transformative sustainable learning establishes the opportunities that will help engineers to achieve their professional goals and generate new knowledge.

🕮 References

Association for the Advancement of Sustainability in Higher Education. Curriculum, 2010.

Blake, Joanna, Stephan Sterling, and Ivor Goodson. Transformative Learning for a Sustainable Future: an exploration of pedagogies for change at an alternative college. *Sustainability*. Volume 5, 2013:5347-5372.

Budwig, Nancy. Concepts and tools from the learning sciences for linking research, teaching and practice around sustainability issues. Current Opinion in Environmental. *Sustainability*. Volume 16, 2015: 99-104.

De la Harpe, Barbara, and Ian Thomas. Curriculum change in universities: Conditions that facilitate education for sustainable development. *Journal of Education for Sustainable Development*. Volume 3, 2009:75-85.

Goldberg, David. E. The missing basics and other philosophical reflections for the transformation of engineering education. In *D. Grasso & M.B. Burkins (Eds.), Holistic Engineering Education* (pp. 145-158). New York, NY: Springer Science, 2010.

Glisczinski, Daniel, J. Transformative Higher Education. *Journal of Transformative Education*. Volume 5 (4), 2007: 317–328.

Heffernan, Kerrissa. Service-learning in higher education. *Journal of Contemporary Water Research and Education*. Volume 199 (1), 2001:1-8.

Hussey, Trevor, and Patrick Smith. Transitions in Higher Education. *Innovations in Education and Teaching International*. Volume 47 (2), 2010: 155–164.

Hutchings, William. *Enquiry-based learning: definitions and rationale*. University of Manchester: Centre for Excellence in Enquiry-Based Learning, 2007.

Jean, Marcus, Coops C. Nicolas, Ellis Shona, and John Robinson. Embedding sustainability learning pathways across the university. *Sustainability Science*. Volume 16, 2015: 7-13.

Johnson, Brian, Michael Duffin, and Michael Murphy. Quantifying a relationship between place-based learning and environmental quality. *Environmental Education Research*. Volume 18 (5), 2012: 609-624.

König, Ariane. Sustainability Science: Changing requisites to higher education in the face of 21st century sustainability challenges. *Current Opinion in Environmental Sustainability*. Volume 16, 2015:105-111.

König, Ariane, Robert Dyball, and Federico Davila. Transforming the World by Transforming the University: Envisioning the University of 2040. *Solutions*. Volume 3 (7), 2016:12-16.

Lavrysh, Yuliana. Transformative Learning as a factor of lifelong learning by the example of vocational education in Canada. *Comparative professional Pedagogy*. Volume 5 (4), 2015: 62-67

Mezirow, Jack, Edward Taylor. *Transformative Learning in Practice: Insights from Community, Workplace, and Higher Education*. John Wiley & Sons, 2011.

Sipos, Yona, Bryce Battisti, and Kurt Grimm. Achieving transformative sustainability learning: engaging head, hands and heart. *International Journal of Sustainability in Higher Education*. Volume 9(1), 2008:68-86.

Sterling, Stephan, Ian Thomas. Education for sustainability: the role of capabilities in guiding university curricula. *International Journal of Innovation and Sustainable Development*. Volume 1(4), 2006: 349-370.

Taylor, Edward, Patricia Cranton. *The Handbook of Transformative Learning: Theory, Research, and Practice*. Jossey-Bass higher and adult education series, John Wiley & Sons, 2012.

Thomas, Ian, Kathryn Hegart, and Sarah Holdsworth. The Education for Sustainability Jig-Saw Puzzle: Implementation in Universities. *Creative Education*. Volume 3, 2012: 840-846.

UNESCO. Education and skills for inclusive and sustainable development beyond 2015. Thematic Think Piece by UN System Task Team on the Post 2015 UN Development Agenda, Paris, 2012. UNESCO.

UNESCO. Teaching and Learning for Sustainable Future, 2010.