

Intellectual development through transformative learning

The potential of undergraduate research and complex challenges

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ABSTRACT: In the present case study, I describe and evaluate the transformative learning potential of authentic research projects that students engage in a course on tissue engineering at Chalmers University of Technology. Through the use of weekly reflective diaries and interviews, I explore how students change their perspective on what learning means to them and the purpose of higher education. Based on the empirical data and scientific literature, I discuss complex challenges as one emerging and deciding factor that helps students to have transformative learning experiences. At the end, some general pointers will be provided on how educators can approach the integration of complex challenges into their own courses and settings.

1 INTRODUCTION

For engineering students, it is increasingly important to develop the ability to engage in *lifelong learning* to be able to adapt to constantly changing problems, contexts, and technologies in our knowledge-based society (Jonassen, Strobel, & Lee, 2006; Kenny et al., 1998). In order to help students to become lifelong learners, *student-centered* and *inductive* teaching methods have become more widely spread in engineering education during the last two decades and have been subjected to great attention in the engineering education research field (Prince & Felder, 2006). These methods include *inquiry-based learning* that place applications and real-life examples first and promote an *active learning* process that encourages the students to take a larger responsibility for their own learning compared to traditional teaching (Kuh, 2008). One particular way to implement inquiry-based learning in higher education is through *undergraduate research*, which allows students to work on authentic research problems and in close contact with doctoral students, post-doctoral fellows, and permanent faculty members (Brew, 2013; Sadler & Mckinney, 2010). Undergraduate research has traditionally been in the form of summer internships (Lopatto, 2009), but has more recently become an integral part of a range of courses at universities all over the world (Corwin, Graham, & Dolan, 2015). In this process of inquiry and research, it is important for students to start seeing knowledge as something that they actively construct and co-constructed, and to realize that it is this process that helps them to learn (Bråten & Strømsø, 2005; Hofer & Pintrich, 2015). Advancing students way of thinking about knowledge, learning, and education are important parts of higher education (Lahtinen & Pehkonen, 2012), and teaching should be concerned about students' *intellectual development*, by facilitating students transition from teacher-centered towards student-centered learning experiences. It is important that students have the chance to become authors of their own learning and development in what Magolda (2007) calls *self-authorship*: "the internal capacity of a student to define his/her own belief system, identity, and relationships".

Students' intellectual development is coupled to what Biesta (2009) called the *socialization function of education* that helps students to become part of a sociocultural context and grow as persons. For students, it is not always easy to see this aspect of education, as neoliberal discourses have reshaped the educational landscape and put a strong emphasis on individualism, competition, and assessment (Giroux, 2002; Harvey, 2005). By emphasizing only the *qualification function of education* that focuses on the acquisition of knowledge, skills, and dispositions that qualify students for doing something (Biesta, 2009), student miss an important part in their educational experience (Olssen & Peters, 2005).

Transformative learning theory offers an interesting perspective that is concerned with both the qualification and socialization function of education and emphasizes the development of a "more critical worldview as we seek ways to better understand our world" (Taylor, 2008), as an crucial part in adult learning. Transformative learning theory conceptualises learning as a perspective

transformation and as “the process of effecting change in a frame of reference.... Frames of reference are the structures of assumptions through which we understand our experiences” (Mezirow, 1997). In other words, transformative learning goes beyond the acquisition of factual knowledge; it changes how students experience the world around them and the identities they develop (Illeris, 2014).

One central question then becomes how to enact this idea of transformative learning and in what ways teachers should frame their interaction with students to promote learning that goes beyond memorizing (Moore, 2005). While this question has been discussed in different venues, there is still a lack of good examples with empirical support from higher education in natural science and engineering. In the present case study, I explore the transformative learning potential of authentic research projects and take a closer look at how students change their perspective on what learning means to them and the purpose of higher education through the use of *reflective diaries* and *interviews* in a *qualitative* research approach.

2 STUDY CONTEXT AND DESIGN

The context for this study is an advanced level course (15 ECTS-credits) on tissue engineering that runs over a five-month period at Chalmers University of Technology, Gothenburg, Sweden. The aim of the course is for students to: 1) gain an overview of the tissue engineering field; 2) understand the fundamental science and technology that form the building blocks of the field; and 3) develop research competencies relevant to the field and a research identity. The tissue engineering course consists of lectures, article review sessions, and a research project to promote inquiry-based learning (Lee, 2012; Prince & Felder, 2006). In the research project, students work in groups of five or six over the entire five-month period of the course together with a mentor. All projects are directly coupled to on-going research at the university. The objective of the project is not only to gain a deeper understanding of the outcome, but also to experience research as it is conducted to gain an understanding of the scientific process. For a more detailed description of the course see (Wallin, Adawi, & Gold, 2017; Wallin, Gold, & Adawi, 2013).

The students' learning experiences and potential transformations were explored using a qualitative research approach. The students were asked to write weekly reflective diaries around specific prompts, see Wallin et al. (2016) for a list with all prompts. Careful prompt design stimulate students to actively reflect upon both, the learning content and their own learning behavior (Jarvis, 2001). The diaries are a writing tool for students that can help them in their reflection process and promote metacognitive skills by providing them with a medium to write down their thoughts (Walker, 2006).

The students' weekly diaries also provide rich continuous data for research, and it is possible to follow the students along during the entire project. To clarify and deepen the understanding of certain aspects of the students' experiences additional interviews were used at the end of the course. It is through the *diary-interview method* that students' experiences can be studied over time and in-depth by building on the strength of both diaries and interviews (Zimmerman & Wieder, 1977). Student participation in writing the diaries and participating in the interviews was voluntary, and all students gave their informed consent that their diaries and interviews could be used as research data.

For the analysis, the data from the reflective diaries and interviews was pooled together and a *general inductive approach* (Thomas, 2006) was used to find emergent themes. It fitted well with the aim I had to focus on how the students describe their own thoughts and the factors that shape their development by letting the data “speak for itself”. In a previous study (Wallin et al., 2017), I took a closer look on the direct learning outcomes of the tissue engineering course: learning to navigate the field, learning to do real research, and learning to work with others; as well as investigate the success factors of the tissue engineering course: a holistic approach to linking teaching and research, engaging students in the whole inquiry process, and situating authentic problems in an authentic physical and social context. In the study presented here, I take one step back and look at the more fundamental aspects of the students learning experience and the transformative potential of the tissue engineering course.

3 RESULTS

From the diaries and interviews, it becomes clear that students not only learn something about tissue engineering, research, and working in a group during the tissue engineering course, but that some students reconsider what learning actually means to them and change their view on higher education itself.

The tissue engineering project puts the students into a new situation, where they work on authentic research projects. The students need to define their own questions, think about what approaches they want to use to answer them, design their experiments, collect and analyze their data, critically discuss their results in the light of the scientific literature, and summarize their findings in a final report and oral presentation. In other words, the students experience what it means to be a researcher and go through all stages of the scientific process (Pedaste et al., 2015). In contrast to many of their previous educational experiences, there are no right or wrong answers, there is not even a question at the start. This new situation together with careful prompt design of the reflective diaries stimulates students to reflect upon their own learning and the processes by which they learn.

Julia describes how she and her group members felt lost at the beginning of the project, because they had so much freedom and did not know how to approach the situation. However in the interview, she also explains that being lost at the beginning was important and that the group got used to it, when she looks back at the course she feels that this experience is important and often missing in other courses:

In the beginning, it felt to us that we had too much freedom, because we did not really know what to do and where to go. We did not know the [scientific field] exactly, so we did not know what we wanted to achieve. So, we felt a bit lost, because it was a bit to open. At the same time, that is good, because you are never in that situation in other courses, because there you have clear instructions to do this and this and this to reach this goal. We got used to [the freedom in this course] over time and in the end we really liked it.

Interview with Julia

In a similar way, Tim reflects in one of his diary entries on how challenging it is to define all the details of a large project. He feels that in many other situations he relies on university systems, teachers and administrators to take care of several aspects in his learning environment, but that the tissue engineering project helps him to be more independent and learn how to learn:

This detail work is still challenging and I think it is something one can easily forget while studying. Sure, we plan our own future and academic progress but we sometimes hand these duties over to the representatives at the university. Such that we get a laid out learning schedule and have some choices along the way. Therefore, it is once again a nice experience to make this self-assessed learning and basically “learn to learn”, once again.

Reflective diary Tim

While the tissue engineering course creates a situation for students that is initially new, difficult, and challenging, the students appreciate it once they have overcome their first resistance and see it as an opportunity. It is through the process of accepting the challenges and seeing the prospects that students also start to question and reconsider more fundamental assumptions about education that they hold.

These students have been growing up with the notion that grades are a central element of education and that good grades are important to progress through the education system to eventually get a job. In the tissue engineering course, they start to question the importance of grades and discover other motivations to work on the projects. Anna writes in her final diary entry about how much she appreciates the project work and how it is much more motivating than exams:

I think working in project form is so great because you really have to dig for relevant information, read a lot and focus on the problem to be solved. Better motivation than studying for an exam!

Reflective diary Anna

Tim explains that grades normally play an important role, but that it was different in the tissue engineering course. He points out that the learning itself was the most important part, which is difficult to measure in grades, but something that nobody can take that away from him:

Of course academic results are important, but in this special case it is not the [grades] that are important but the knowledge I can gather and keep for myself. Nobody can take that away from me... We gained so much experience. The amount of experience is hard to measure.

Reflective diary Tim

This shift in focus from learning for grades towards learning to gain experience and knowledge means that these students begin to see their own education as something more than just an obstacle course that one needs to complete to get a job. They appreciate learning itself and want to understand the world around them, instead of focusing mainly on assessment and grades. They transform their perspective on the value of learning and what higher education is for.

4 DISCUSSION

The ability to follow students over time through the weekly diaries is of great value, as it opens the possibility to see their development and transformation. Reading the students diaries and listening to them in the interviews offers an interesting departure point to better understand how they conceptualize their own learning and education. On the one hand, it is disturbing and frightening to see the initial expectations students have on being provided with ready-made pieces of knowledge that are later tested in exams, where there are clear answers and grades that measure progress. On the other hand, it is promising and thrilling to see how much students can grow when adjusting the way we teach and interact with them.

The transformative learning experience that some students have in the tissue engineering course is not bounded by the context or content itself, but is concerned with the very action of learning and higher education itself. This change in frame of reference regarding of what learning means to them and what higher education is for is an important step for students in their intellectual development (King & Magolda, 1996). The transformative learning experiences that the students describe in this study help them to become the author of their own learning and development (Magolda 2000 & Magolda 2001). Self-authorship is a crucial part in a higher education system that rightfully places more and more emphasis on student-centered teaching, because if students fail to see learning as an *active* process, where knowledge is constructed and co-constructed, they will not fully profit from student-centered teaching. Furthermore, the ability to regulate their own learning and appreciate it are key factors in being able to engage in lifelong learning (Muis, 2007). It will help students to be prepared for a world that is constantly changing or as Nilson (2013) put it: “only lifelong learners will be able to keep up with the explosive growth of knowledge and skills in their career and to retool into a new career after their previous one runs its course”.

It is through their involvement in research, an authentic and central activity at the university (Jenkins & Healey, 2009), that students can realize that the university is more than a place to get a degree from. From my experience with the tissue engineering course, I argue that allowing students to experience complex challenges that are potentially disruptive are a key element if we want students to have transformative learning experiences. It means that teachers and students alike need to take risks and commit themselves to the experience. Bieste describes in his book “Beautiful Risk of Education” (2013) the importance of opening up the possibility that students and teachers can walk away from a course with having gotten nothing out of it. By taking this risk, there is at the same time the chance that both have a transformative learning experience “that takes you and that student to new places or new ways of thinking and new models of imitation or you name it in terms of what could come out of it” (Collier & Friend, 2016). Engaging students in on-going research projects, like in the tissue engineering course, is a risk and from my experience with the course things do go wrong sometimes, but at the same time it creates possibilities for students and their intellectual development that are otherwise rare in higher education.

It is important that higher education exposes students to complex challenges that confuse them and where they feel lost. The disruptive nature of the situation and the strong contrast to previous experiences in education stimulates the students to question and reconsider their own frame of reference (Illeris, 2014; Moore, 2005). In these transformative learning experiences students will be in a transition state, where the old frame of reference is rejected, but the new one is not yet fully in place (Meyer & Land, 2005). If we want to help our students and provide them with more than facts and figures in the subjects that we teach, it is our responsibility to create a safe environment, where we can challenge the students and focus on their intellectual development. Providing students with opportunities for this type of transformative learning is particular important in engineering and science education, as some studies show that students hold more naïve ideas about learning and the purpose of education in these fields (Felder & Brent, 2004). It is important that we, as teachers of science and engineering, continue to develop and reconsider our teaching approaches and broaden the scope of higher education in these fields to go beyond merely focusing on facts, principles, and procedures presented in a dualistic mode (Wankat, 2002).

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REFERENCES

- Biesta, G. J. J. (2009). On the weakness of Education. *Philosophy of Education*, 354–362.
- Biesta, G. J. J. (2013). *Beautiful Risk of Education*. New York, NY: Routledge Taylor & Francis Group.
- Bråten, I., & Strømsø, H. I. (2005). The relationship between epistemological beliefs, implicit theories of intelligence, and self-regulated learning among Norwegian postsecondary students. *British Journal of Educational Psychology*, 75(4), 539–565.
- Brew, A. (2013). Understanding the scope of undergraduate research: A framework for curricular and pedagogical decision-making. *Higher Education*, 66(5), 603–618.
- Collier, A., & Friend, C. (2016). Questioning Learning. *Hybrid Pod*, (Episode 9).
- Corwin, L. A., Graham, M. J., & Dolan, E. L. (2015). Modeling course-based undergraduate research experiences: An agenda for future research and evaluation. *CBE Life Sciences Education*, 14(1), 1–13.
- Felder, R. M., & Brent, R. (2004). The Intellectual Development of Science and Engineering Students. Part 1: Models and Challenges. *Journal of Engineering Education*, 93(4), 269–277.
- Giroux, H. (2002). Neoliberalism, Corporate Culture, and the Promise of Higher Education: The University as a Democratic Public Sphere. *Harvard Educational Review*, 72(4), 425–464.
- Harvey, D. (2005). *A Brief History of Neoliberalism*. New York, NY: Oxford University Press, Inc.
- Hofner, B. K., & Pintrich, P. R. (2015). The Development of Epistemological Theories: Beliefs About Knowledge and Knowing and Their Relation to Learning. *Review of Educational Research*, 67(1), 88–140.
- Illeris, K. (2014). Transformative Learning and Identity. *Journal of Transformative Education*, 12(2), 148–163.
- Jarvis, P. (2001). Journal writing in health education. *New Directions for Adult and Continuing Education*, 2001, 79–86.
- Jenkins, A., & Healey, M. (2009). Developing the student as a researcher through the curriculum, 1–5.
- Jonassen, D., Strobel, J., & Lee, C. B. (2006). Everyday Problem Solving in Engineering: Lessons for Engineering Educators. *Journal of Engineering Education*, 95(2), 139–151.
- Kenny, S. S., Alberts, B., Booth, W. C., Glaser, M., Glassick, C. E., Ikenberry, S. O., ... Yang, C. N. (1998). *Reinventing undergraduate education: A blueprint for America's research universities*. (The Boyer Commission on Educating Undergraduates in the Research University, Ed.). New York, NY: Stony Brook.
- King, P. M., & Magolda, M. B. B. (1996). A Developmental Perspective on Learning. *Journal of College Student Development*, 37(2), 163–173.
- Kuh, G. D. (2008). *High-Impact Educational Practices*. Washington, DC: Association of American Colleges and Universities.
- Lahtinen, A.-M., & Pehkonen, L. (2012). "Seeing things in a new light": conditions for changes in the epistemological beliefs of university students. *Journal of Further and Higher Education*, 9486(October 2014), 1–19.
- Lee, V. S. (2012). What is inquiry-guided learning? *New Directions for Teaching and Learning*, 2012(129), 5–14.
- Lopatto, D. (2009). *Science in Solution: The impact of undergraduate research on student learning*. Tucson, AZ: Research Corporation for Science Advancement.
- Magolda, M. B. B. (2007). Self-authorship: The foundation for twenty-first-century education. *New Directions for Teaching and Learning*, 2007(109), 69–83.
- Meyer, J. H. F., & Land, R. (2005). Threshold concepts and troublesome knowledge (2): Epistemological considerations and a conceptual framework for teaching and learning. *Higher Education*, 49(3), 373–388.
- Mezirow, J. (1997). Transformative Learning: Theory to Practice Transformative Learning Theory. *Transformative Learning (Mezirow)*, (74), 5–12.
- Moore, J. (2005). Is Higher Education Ready for Transformative Learning?: A Question Explored in the Study of Sustainability. *Journal of Transformative Education*, 3(1), 76–91.
- Muis, K. R. (2007). The Role of Epistemic Beliefs in Self-Regulated Learning. *Educational Psychologist*, 42(3), 173–190.
- Nilson, L. B. (2013). *Creating Self-Regulated Learners: Strategies to Strengthen Students' Self-Awareness and Learning Skills*. Sterling, VA: Stylus Publishing, LLC.
- Olszen, M., & Peters, M. A. (2005). Neoliberalism, higher education and the knowledge economy: from the free market to knowledge capitalism. *Journal of Education Policy*, 20(3), 313–345.
- Pedaste, M., Mäeots, M., Siiman, L. a., de Jong, T., van Riesen, S. a. N., Kamp, E. T., ... Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review*, 14, 47–61.
- Prince, M., & Felder, R. (2006). Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases. *Journal of Engineering Education*, 95(2), 123–138.
- Sadler, T. D., & McKinney, L. (2010). Scientific Research for Undergraduate Students: A Review of the Literature. *Research and Teaching*, 39(5), 43–49.
- Taylor, E. W. (2008). Transformative learning theory. *New Directions for Adult and Continuing Education*, 2008(119), 5–15.
- Thomas, D. R. (2006). A General Inductive Approach for Analyzing Qualitative Evaluation Data. *American Journal of Evaluation*, 27(2), 237–246.
- Walker, S. E. (2006). Journal writing as a teaching technique to promote reflection. *Journal of Athletic Training*, 41(2), 216–221.
- Wallin, P., Adawi, T., & Gold, J. (2016). Reflective diaries – A tool for promoting and probing student learning. In *12th International CDIO Conference*. Turku, Finland.
- Wallin, P., Adawi, T., & Gold, J. (2017). Linking teaching and research in an undergraduate course and exploring student learning experiences. *European Journal of Engineering Education*, 42(1), 58–74.
- Wallin, P., Gold, J., & Adawi, T. (2013). Tasting Genuine Research in a Course on Tissue Engineering. In *41th Annual SEFI Conference, Leuven, Belgium*.
- Wankat, P. C. (2002). *The Effective, Efficient Professor: Teaching, Scholarship, and Service*. Boston, NJ: Allyn and Bacon.
- Zimmerman, D. H., & Wieder, D. L. (1977). The Diary: "Diary-Interview Method." *Urban Life*, 5(4), 479–499.