Development of learner autonomy in student-centred learning environments in engineering

D. Reyes-Viviescas[1]
PhD Researcher
University of Strathclyde
E-mail: diogenes.reyes-viviescas@strath.ac.uk
Glasgow, UK

E. Ventura-Medina
Senior Lecturer
University of Strathclyde
E-mail: esther.ventura-medina@strath.ac.uk
Glasgow, UK

T. Anderson
Senior Teaching Fellow
University of Strathclyde
E-mail: tony.anderson@strath.ac.uk
Glasgow, UK

C. Mio
Lecturer
University of Glasgow
E-mail: Cristina.Mio@glasgow.ac.uk
Glasgow, UK

Conference Key Areas; Engineering Skills, Teaching and Learning Methods

Keywords: Project-based learning, self-regulation, autonomy

ABSTRACT

Engineering graduates are required not only to have strong communication, problem-solving and teamwork skills but also the ability to face and adapt to new situations [1]. Hence, there is an evident need for developing life-long learning skills and particularly in fostering self-regulation of learning in engineering programmes. Project-Based Learning (PjBL) is a teaching pedagogy that supports the development of intellectual skills and autonomy through self-regulation.

Individual self-regulation of learning has been studied over the years in a range of education situations [7,14]. As teamwork becomes commonplace in education, the need to study team regulation has become apparent and models that include social and cognitive processes during teamwork have emerged [2]. However, new empirical evidence is still required to develop models of shared regulation in groups.

This study builds on the body of empirical evidence about shared regulation focusing on Project-Based Learning environments. It investigates how teams of engineering

[1] D. Reyes-Viviescas
E-mail: diogenes.reyes-viviescas@strath.ac.uk

students actually develop shared team regulation and how this is related to individuals' self-regulation. The study uses data from students' project meetings during a one-semester long project as part of a Chemical Process design course.

As the emphasis of the study is in describing and analysing how shared regulation takes place within a group context, focusing the attention on verbal and non-verbal mechanisms as indicators of shared regulation displayed by the students; naturalistic data of teams of students are gathered while carrying out PjBL meetings (~5) via video recording (~10 hours). Transcripts of conversations/actions are coded in the first instance to describe what takes place and then to support the analysis. These data enable the identification of elements of regulatory behaviour as displayed through language.

1. INTRODUCTION

With the rapid and unstoppable evolution of technology and current market conditions, society is facing unprecedented and increasingly urgent challenges [3] that clearly need to be addressed and solved using reasonable solutions by well-versed professionals. In addition, the flexibility and ability to face new situations are imperative in a fast-paced and dynamic working environment, which requires the development of life-long learning skills.

Thus, the role of Higher Education Institutions (HEI) is vital in delivering the appropriate training, in accordance to the current and forthcoming necessities of the world. The constant communication between professional bodies, industry and HEI has served as an important bridge to get significant input into the key skills required [4]. The most prominent skills reported are problem-solving and teamwork [5].

It is a fact that skills need to be kept up to date, as the tasks, methodologies and activities are rapidly changing in any working environment. The university is the scenario where students can be trained hands on using the latest developments and techniques to come up with logical solutions to real problems [5].

In this context, the capability to self-regulate our own learning is essential [6]. Self-regulation refers to the set of abilities to plan and monitor our own development, which are fundamental for learners' progress towards building new capabilities and improve the ones they have already developed or inherited [7].

In terms of learning processes, student-centred learning pedagogies are teaching strategies that support the development of intellectual skills and autonomy through self-regulation [8].

Besides, the importance and application of pedagogies such as Problem-Based Learning (PBL), provide the perfect setting to investigate and later describe how shared regulation is displayed by the students, as a group of individuals. Noting that they who work in teams toward a common goal under some limitations and, having to manage and organize a series of tasks and processes [9].

A number of studies have been done in different learning environments, which support the idea that shared regulation can be developed [2]. However, more empirical evidence is needed to make a stronger and better description of the mechanisms which clearly described interactions (e.g. perception and negotiation of common goals, definition of strategies to succeed with the tasks, and evaluation of goal progress); which ultimately will provide clear directions on how students can be aware of the

regulatory processes that are taking place, consequently be able to adjust what could be out of track [9].

At this stage of this research, the clear identification of elements connected to team self-regulation is essential to understand better, how they take place while students undertake a project assignment, which later, will be used as the most important source for the construction of a model that clearly reflects on the findings. In addition, there is a space that needs more investigation, how team self-regulation is linked, direct or indirectly, to the enhancement of students' task performance, which could potentially be identified along the video as the analysis takes place.

The aim of this study is to find how students effectively develop self-regulation while working in teams, at both, individual and group level when dealing and undertaking Project-Based Learning (PjBL) activities in a Chemical Engineering design course.

The research questions addressed here are how students use reflective strategies to progress towards team goals, and what self-regulatory strategies the team as a collective use to fulfil their goal.

2. BACKGROUND

Problem-based learning (PBL) is a pedagogical approach where a defined problem is used as preliminary point of the learning process. Typically, the problem is defined according to the specific learning needs and could be based in real-life problems, and sometimes in hypothetical ones, to meet the educational purposes and be solved potentially using investigation, explanation, and resolution [10].

Project-Based Learning is a pedagogy that builds learning process around projects [11] with professional skills development, disciplinary knowledge, and independent and flexible learning, while accommodating a wide range of students' learning needs [12] with the final generation of a genuine product or outcome [11].

De Graaf and Kolmos [10] distinguish two models in educational PBL practices; Problem-based and Project-organised learning. In Project-organised learning, they point to the fact that, the scope (breadth and complexity) of the project (problem-based) can determine the level of student involvement.

This work will be focused on the use of Project-based learning (PjBL) as the main learning pedagogy. It also makes a distinction here between PjBL and more general PBL as it use a wide scope project (i.e. broad and complex). PjBL encompasses a series of goals that aim to help students develop knowledge and skills that can be used across different subjects, for effective problem-solving and for collaboration [8]. Project-based science also promotes the activation of intrinsic motivation to improve performance when dealing with problems [13].

Self-regulation of learning (SRL) refers to the process as the self-generation of thoughts and emotions, which are applied methodically and strategically as required to generate an effect on the learning process [3]. It is said that PjBL supports and promotes the self-regulation process, due to the nature of the learning progression while students are constructing mental representations for giving feasible solutions to address a diverse type of problems [8].

Zimmerman [14] developed one of the first and principal self-regulated learning cyclical models, where he tried to explain the different strategies taking place and

influencing the self-regulated learning process. In his studies, Zimmerman identified three main phases, represented in his model (see Figure 1), that usually are displayed while students are attempting to solve a problem or an assignment, and that ultimately will help learners to be focused on the actual tasks and as a result enhanced their performance [15].

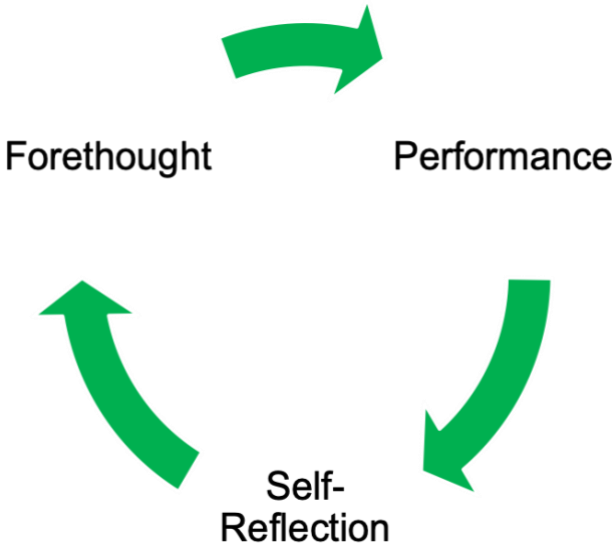

Figure 2. Zimmerman Model. Adapted from Zimmerman [15].

The first stage in the Zimmerman's model is known as the forethought phase, which is the moment when the student faces the task at first, analyses it, sets goals and establishes a plan on how to reach them. Once the previous stage is completed, the second (the performance phase) starts. During this phase, learners attempt to carry out the task while monitoring their progress using a series of self-control strategies, so to maintain themselves completely involved and determined to finish the task. In the third stage, the self-reflection phase, learners evaluate how their performance was, making a clear judgement of their failure or accomplishment [16]. This stage has a significant importance and relevance to the cycle, for both, the conclusion of the current sequence. First, because of the impact that could have caused to the learner's experience and learning efforts, and second, a direct influence on the forethought phase, as this is the starting point of an upcoming cycle, in the case a new challenge is due to be faced [15].

When students are dealing with an assignment, tasks, or even projects, they normally require the continuous support of a tutor, who can give them indications or insights that could lead to the successful development of the work [13]. Therefore, there is still much work or training to be deployed with the students so they could reach a point where self-regulation and autonomy becomes the rule; subsequently, the right use of the available tools (e.g., books, online contents) and teaching elements, can become a regular activity as part of the learning process, so the tutor' support could be less while the student's independence is high [17].

It is important to mention and make clear that the self-regulation strategies, as proposed by Zimmerman [14], might vary when they are applied by individuals within

a group or even when taking place in a group context, due to the limitations and constraints that students can face when working with others.

In different studies and analyses that have been done, SRL models provide a reasonable picture of the processes taking place [7]. However, there is still much to do to comprehend SRL mechanisms in detail and see how they take place, when they are used or how they are activated by learners along the interaction and cognition stages [14].

Stefanou et al. [18] have used mechanisms in teaching environments (e.g. choosing group members, setting deadlines for assignments, seating arrangements, and providing materials) which have demonstrated to lead to independent learning. In spite of this, whether or not independent learning lasts in the longer term depends on the learners being engaged in deep learning and being highly motivated. However, it has been found that organizational and procedural autonomous strategies tend to support the process to a lesser extent than cognitive strategies (e.g. discussion of multiple approaches to the problems, justification of solutions or having sufficient time for the decision-making stage) that may take students to a self-motivated and unlimited participation in learning [19]

Perels et al. [20] conducted a study where a full training related to self-regulation and problem-solving skills was given to a group of students in a German grammar school, it is worth to say that the study was done in a senior children school rather than in a university with undergraduate participants. In this study, they adapted Zimmerman's model focusing their attention on the motivational aspects that influence students' performance the most. The training combined self-regulatory components such as goal setting, motivation, volitional strategies, self-efficacy and self-reflection, and problem-solving approaches to coach experimental tactics (working forward and backwards, what keep constant). A series of preliminary pre-tests were applied to the students to establish a base line and allowed comparison of their performance before and after the training of their current performance. It was found that after this intense training an effective improvement in students' performance when applying problem-solving skills. However, this was not the case for the self-regulation component, where results gave indicators of enhancement, but not as strong as those in problem-solving skills. This is a clear indication that these self-regulatory strategies are more difficult to teach compared to problem-solving skills. Nevertheless, the combination of both pedagogical strategies appears to be beneficial to learners' performance.

Hadwin, Järvelä and Miller [2] have worked together in self-regulated learning, focussing their attention on groups, and how the team members cooperate efficiently to accomplish group work; establishing a collective setting, conveying and allocating tasks and formulating strategies. They developed a model that proposed the existence of three modes of regulation in a group working environment: self-regulation (SRL), co-regulation (CoRL), and shared regulation (SSRL) (see Figure 2).

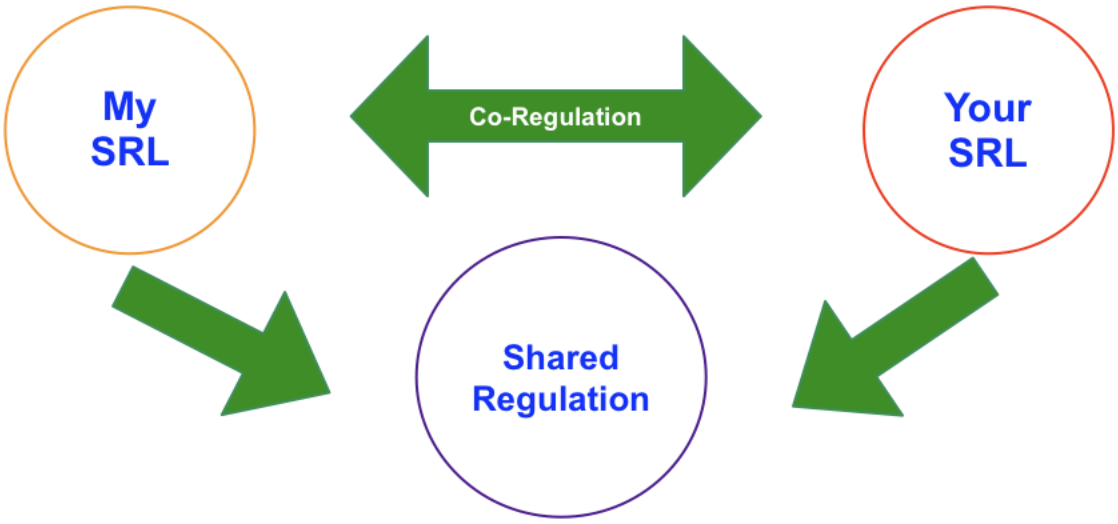

Figure 2. Regulation in a group working environment. Adapted from Hadwin et al. [21].

These modes are defined as followed [21] and [9]:

SRL in a collaborative setting refers to the individual's action within the group that is connected to the way adaptation is performed while there is an interaction with other participants of the team.

CoRL is defined as the affordances and restrictions that motivate the students' allocation of planned activities, performing, deliberation, and adjustment that usually occur when there is interaction with other learners or members of the group, so temporary help may appear when any of the team members needs support in order to solve his/her assigned task.

SSRL is the manner when the diverse perceptions, adaptations, tasks, and goals and plans are taken across the whole group.

3. RESEARCH METHODOLOGY

One advantage of studying teams is the fact that they are frequent not only in academia but also in companies and real life. Thus, they create the perfect framework to be able to identify patterns of how students develop shared regulation, via common behaviours that individuals show when dealing with tasks to that involve mechanisms of regulation.

The study centres on exploring the function of reflection and self-regulation in the development of intellectual skills that have the potential to foster autonomous learning. Thus, the study uses data from students' project meetings during a one-semester long project as part of a Chemical Process design course. The class has been divided into groups, which are made of 6-7 members each, for the development of the project assignment, which is the proposal and basic engineering design of a plant for Nitric Acid production for the data currently under analysis. In the group that has been video recorded there are 5 students, being slightly smaller.

The research questions mentioned earlier are explored by collecting and analysing data using a qualitative approach. The data consist of video recordings of student-group work meetings as well as students' reflections on the class: either written or oral

and individually and as a group. In addition, the study will also seek to use video recordings from a previous study done during 2016 and 2017 within the SkIL Research Group of the Chemical and Process Engineering department from the University of Strathclyde, using the same setting (i.e. participants in PjBL groups during project meetings). The study has been granted Ethical approval by the Departmental Ethics Committee. Furthermore, students' participation in the video recording sessions was volunteered.

Due to the nature of the data that will be analysed, two analytical methodologies are going to be explored, namely thematic and content analysis. Thematic analysis is a method for the identification, analysis and later report of common patterns inside data [22], which is known as a qualitative descriptive method [23]. Content analysis is a more "strict and systematic set of procedures for the rigorous analysis, examination and verification of the contents of written data" [24].

Furthermore, self-regulated learning strategies such as self-evaluating (i.e., I check my assignment to make sure it was right), goal setting and planning (e.g. I start preparing my exams 2 weeks before they happen), organising and transforming, seeking information, keeping records and monitoring, among others [16], that potentially could be shown by participants are going to be analysed and compared. The previously said will help describe common characteristics which indicate learners' autonomous behaviour.

The core source of data for this research is video recording of students' project meetings. To this point, 5 meetings have been video recorded with an equivalent of 10 hours of filming. Here, the importance of capturing naturalistic data as is, is an essential element to recognise features of autonomous behaviours, which might be displayed by the students in a setting where the absence of a tutor is of significant relevance, since they can behave normally as they are. Equally important is the fact that video recordings allow a better comprehension of the dynamics that could emerge as students work through the diverse tasks.

Since video recordings give an unfiltered reflection of action they are more powerful than merely human observations [24]. Moreover, video recordings can be played numerous times, allowing to obtain detailed evidence from students' interactions [25], which can be analysed using categories identified within the literature. Finally, video recording also allows the coding of actions, for example, non-verbal behaviours. The use of video footage will allow a broader range of teams to be studied as the video recording process can be done with more than one team in the same academic year, and subsequently, provide conclusions for a wider range of cases.

Transcription is one of the most complex tasks to cover as part of the research. Here a speech representation of the participants' talks is going to be written, where verbal (full transcription of speech, including errors) and non-verbal data (i.e., gaze and gestures) will be collected.

Once the transcription is done, the next step is to group the video transcription elements into defined SSRL categories identified as codes. This helps to analyse the spectrum as a whole, and in this way, build a robust model that has enough elements that supports the SSRL models.

4. PRELIMINARY FINDINGS

Preliminary findings indicate that use of these pedagogies does promote regulation but there is still a need to comprehend clearly how the mechanisms take place [26]. From the data, it has been observed that the phases described in the literature by Hadwin, Järvelä and Miller are displayed by the students and emerged as they undertake the project tasks.

In regards to whether the changes in students' level of SRL is linked to improvement in their overall academic achievement, researchers claim to see an enhancement in students' performance, however, more field research needs to be done to obtain a clearer picture of the relation between the strategies applied and the outcome generated as a result of them [27].

Even though, SRL models provide a quite specific picture of their processes, there is still much need to understand SRL mechanisms more precisely as to identify when they are applied or performed by learners [16]. Further, there is a need to understand the continuum of self-regulation, co-regulation and shared-regulation of students working in teams by using data that captures students working together over long periods of time [2]. The present study contributes to develop precisely the empirical basis on which Shared-regulation models can be informed.

5. NEXT STEPS

As the research advances through the continuous transcription process, a preliminary coding structure will be stablished which would serve as an analytical scheme, being refined and tuned based on the information that is extracted from the transcripts, giving place to a coding scheme for a later analysis of the elements present. Some of the codes are pre-defined based on current concepts available in the literature about SRL while others might emerge from the data itself.

Thus, the SSRL model could be understood, and a full justification of the analytical framework could be given, leading to a stronger and mature structure, which will reflect the findings and draw significant conclusions from the investigation. Hence, a link between pragmatic and meta-analytic evidence on SSRL could be established that directly connects self-regulated learning and academic performance with a totally new perspective [26].

REFERENCES

[1] Northwood, M. D., Northwood, D. O. and Northwood, M. G. (2003), Problem-Based Learning (PBL): From the Health Sciences to Engineering to Value-Added in the Workplace, Global Journal of Engineering Education, Vol. 7, pp. 157-164.

[2] Järvelä, S. and Hadwin, A. F. (2013), New Frontiers: Regulating Learning in CSCL, Educational Psychologist, Vol. 48, No 1, pp. 25-39.

[3] Zimmerman, B. J. (1990), Self-Regulating Academic Learning and Achievement: The Emergence of a Social Cognitive Perspective, Educational Psychology Review, Vol. 2, No 2, pp. 173-201.

[4] Kirby, J. R., Knapper, C., Lamon, P. and Egnatoff, W. (2010), Development of a scale to measure lifelong learning, International Journal of Lifelong Education, Vol. 29, No 3, pp. 291-302.

[5] Lucas, B., Claxton, G. and Hanson J. (2014), Thinking Like an Engineer. Implications for the Education System. Royal Academy of Engineering London.

[6] Macaskill, A. and Taylor, E. (2010), The Development of a Brief Measure of Learner Autonomy in University Students, Studies in Higher Education, Vol. 35, No 3, pp. 351-359.

[7] Schunk, D. H. and Ertmer, P. A. (2000), Chapter 19 - Self-Regulation and Academic Learning: Self-Efficacy Enhancing Interventions. Handbook of Self-Regulation, Academic Publisher, San Diego, pp. 631-649.

[8] Dolmas, D., De Grave, W., Wolfhagen, I. and Van Der Vleuten, C. (2016), Problem-Based Learning: Future Challenges for Educationals Practice and Research, Medical Education, Vol. 39, No. 7, pp. 732-741.

[9] Hadwin, A., Järvellä, S. and Miller, M. (2018), Chapter 6 - Self-Regulation, Co-Regulation, and Shared Regulation in Collaborative Learning Environments, Handbook of Self-Regulation of Learning and Performance, Schunk, D. H. and Green J . A [ed], Routledge, New York, pp. 83-107.

[10] De Graaf, E. and Kolmos, A. (2003), Characteristics of Problem-Based Learning, International Journal of Education Engineering, Vol. 19, No 5, pp. 657-662.

[11] Thomas, J. W. (2000), A Review of Research on Project-Based Learning. Autodesk Foundation, San Rafael, pp.1-46.

[12] Warnock, J. N. and Mohammadi-Aragh, M.J. (2016), Case Study: Use of Problem-Based Learning to Develop Students' Technical and Professional Skills, European Journal of Engineering Education, Vol. 41, No 2, pp. 142-153.

[13] Hmelo-Silver, C. E. (2004), Problem-Based Learning: What and How Do Students Learn?, Educational Psychology Review, Vol. 16, No 3, pp. 235-266.

[14] Zimmerman, B. J. (1995), Self-Regulation Involves More than Metacognition: A Social Cognitive Perspective, Education Psychologist, Vol. 30, No. 4, pp. 217-221.

[15] Zimmerman, B. J. (1998), Chapter 1 - Developing Self-Fulfilling Cycles of Academic Regulation: An Analysis of Exemplary Instructional Model, Self-regulated learning: From teaching to self-reflective practice, Schunk, D. H. and Zimmerman, B. J. [ed.], Guilford, New York, Vol 1, pp. 1-19.

[16] Zimmerman, B. J (1989), A Social Cognitive View of Self-Regulated Academic Learning, Journal of Educational Psychology, Vol. 81, No 3, pp. 329-339.

[17] Macaskill, A. and Denovan, A. (2013), Developing autonomous learning in first-year university students using perspectives from positive psychology, Studies in Higher Education, Vol. 38, No 1, pp. 124-142.

[18] Stefanou, C. R., Perencevich, K. C., DiCinto, M. and Turner, J. C. (2004), Supporting Autonomy in the Classroom: Ways Teachers Encourage Student Decision Making and Ownership, Educational Psychologist, Vol. 39, No 2, pp. 97-110.

[19] Brophy, J. (1998), Classroom management as socializing students into clearly articulated roles, Journal of Classroom Interaction, Vol. 33, No 1, pp. 1-4.

[20] Perels, F., Gürtler, T. and Schmitz, B. (2005), Training of self-regulatory and problem-solving competence, Learning and Instruction, Vol. 15, No 2, pp. 123-139.

[21] Hadwin, A. F., S., Järvelä and Miller, M. (2011), Self-Regulated, Co-Regulated, and Socially Shared Regulation of Learning, Handbook of Self-Regulation of Learning and Performance, Zimmerman, B. J. and Schunk, D. H. [ed.], Routledge, New York, pp. 65-84.

[22] Braun, V. and Clarke, V. (2006), Using thematica in psychology, Qualitative Research in Psychology, Vol. 3, pp. 77-101.

[23] Vaismoradi, M., Turune, H. and Bondas, T. (2013), Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study, Nursing and Health Sciences, Vol. 15, pp. 398-405.

[24] Cohen, L., Manion, L. and Morrison, K. (2011), Research Methods in Education, 7th Edition, Routledge, Abingdon, pp 564-573.

[25] Jordan, B. and Henderson, A. (1995), Interaction Analysis for Qualitative Researchers. 2nd Edition. SAGE, Los Angeles.

[26] Panadero, E. (2017), A Review of Self-regulated Learning: Six Models and Four Directions for Research, Frontiers in Pyschology, Vol. 8, No 422, pp. 1-28.

[27] Zimmerman, B. J. (2008), Investigating Self-Regulation and Motivation: Historical Background, Methodological Developments, and Future Prospects, American Educational Research Journal, Vol. 45, No 1, pp. 166-183.