INTERNATIONAL CONFERENCE ON ENGINEERING AND PRODUCT DESIGN EDUCATION
6 & 7 SEPTEMBER 2012, ARTESIS UNIVERSITY COLLEGE, ANTWERP, BELGIUM

WHAT INFLUENCES STUDENT INNOVATION?

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ABSTRACT
This paper investigates how elements of the learning environment influence student innovation. In detail, the paper addresses students' perceived efficacy and their motivation to work in two parallel engineering design projects. Rather than rediscovering evaluation, student perceptions determine a project's overall efficiency by individual reflection on the effort made. Based on previous research on student efficacy [1], this study takes a student-centric point of view where the self-efficacy is grounded in students' intrinsic motivation for work. The paper's principal idea is to investigate how different elements of interaction cause students' beliefs to shift individually and in groups. A qualitative approach has been used where the results have been collected through structured questionnaires with project participants. Results show that the internal proximity and joint motivation to work have positive influence together with lecturer/coach presence, informative clarity and valuable input. Reported differences clearly separated the teams with several useful features of course analysis to consider for future work.

Keywords: Learning environment, student efficacy, project course, innovation, facilitation

1 INTRODUCTION

Innovation is fostered in nurturing environments that allow divergent thinking, freedom and intrinsic motivation. Engineering education literature has long had topics related to learning environments as a foundation enabling efficient learning. Since engineering design carries a strong socio-technological dimension, the learning involves interaction patterns and mutual influences that can be difficult to obtain. Students' perceived learning environments provide a basis for distinct contextual premises to evolve. Although the learning environment is expressed as central in achieving high-level performance [1-3], the approaches to systematically tracing student efficacy seem quite vague. This puts the interactive elements in focus as direct causes of a motivational learning environment. The day-to-day interaction between students corresponds to the core of influencing elements that also resides in the relationships established with lecturers/coaches and industrial sponsors. The engagement level of interacting peers and level of change commitment should reward educational practices. Establishing a climate where innovation is born does not happen by simply engaging students in collaborative activities. It is essential to understand that the foundation of such learning is interdependence, which means that highly engaging and productive learning environments require the simultaneous presence of a need to work together (interdependence such as a challenging problem, a complex project, difficult concepts, multiple perspectives) and a high level of individual and mutual accountability [4]. The reality intercept allows students to develop vital craftsmanship skills and experiences. These pragmatic skills are derived from the user needs and project requirement specifications provided by the industrial sponsor. This project-based course model has been considered an important component to develop a robust engineering competence [5][6]. Past research suggests that courses of this kind appear to improve retention, student satisfaction, diversity, and student learning [7]. However, as learning and project activities unfold there is a need for having a course climate that facilitates and appreciates learning and the subsequent activities involved.

2 LEARNING ENVIRONMENT

Learning, particularly in the context of engineering design projects, provides a unique opportunity to prepare students for complex and multifaceted situations of work life. Past studies present a framework for understanding and appreciating supportive blocks of the learning environment involving four cornerstones: context, content, facilitation and assessment [3]. The structural building blocks needed for efficient learning create a working environment that also challenges students to search for new and innovative solutions at the focal point. Students working in project groups are characterized by integrative work efforts. Their level of understanding is interlinked with the apprehension of context- and content-related aspects and lecturer-devoted activities through facilitation and assessment [8]. As a consequence, coaching activities are central for providing good learning environments and enabling students' intuitive knowledge [2].

Assessment concerns the balance between being a judgmental course lecturer, on the one hand, and being the facilitating coach on the other hand, a situation that has been seen as conflicting and unsuitable [9]. To keep objectivity in assessment measures, constructive alignment matches activities, assessment and objectives through the facilitation of the lecturer [10]. Student-centric learning tends use a greater variety of assessment methods in combination with greater emphasis by enrolled faculty (i.e. coaches) on awareness of the responsibility for encouraging students' own development of deep-level understanding through explanation, enthusiasm and empathy.

A project group's innovative achievements have been positively correlated with high cultivating effects on learning environment, developmental feedback and cohesion of the project group [11]. Past studies show that conceptions of both learning and coaching by faculty also affect their approaches to the interaction with students [12]. In the chain of interrelated influences, coaches' approaches to helping students also affect their students' approaches to learning and fulfilment of learning outcomes.

The way faculty is clear and structured has been shown to influence the overall effectiveness in the interaction with students [13]. In engineering design projects of this character three distinct motivational modes can be derived, i.e. student-student, P or P_x; student-coach, C; student-firm, F. All three constitute student-centric modes that evoke deep approach learning.

Tracking student perceptions is difficult. A systematic approach such as Ambrose et al's proposed efficacy model [1] provides at least a structural setting in how to proceed. By shifting point-of-view the teacher perspective is put aside a self-efficacy rating is applied. Individual's preconception of their own capabilities to meet task-specific demands or execution of a distinct action is taken into consideration [14].

The motivational role of perceived efficacy level is linked with performance, where high levels of self-efficacy have a fostering effect on the learning environment and levels of learning, whereas low levels show a weakening relationship [15]. Rooted in a previous study [16], this study proposes an inverted model for understanding the students' self-efficacy through the influences of interaction modes relevant to the learning environment. As a consequence the student perspective is used to understand the unseen elements that affect the student learning environment.

3 RESEARCH DESIGN

The project course emphasizes a process perspective with relatively large groups. The offset for this study relate to four cases running annually and 175 responses in total. Retrieving data from two consecutive years involving 15 and 16 students respectively the first year and ten in each project group the second year. The study was carried out in the master level course of 'Integrated product development' (IPD) encompassing 24 ECTS that run three quarters of a year. For each year the empirical data were collected in two separate periods of time throughout the student projects. Student respondents were all active participants in one of four project groups referred to as BF, LL, EM and OP. The first occasion was at the time of the project's first tentative concept presentation in the spring semester. The second occasion was mid-late fall, a period of intense workload for the students as they are finalizing prototypes and overall finishing. Since inclusion the second batch of data ('Fall') concerns an on-going project the data is beyond the scope for this paper, consequently year two have merely one data input although using the same questionnaire.

Year one included 56 responses, distributed by 27 and 29 at the two occasions. Year two concerned 19 responses (EM: 9 and OP:10) collected using the same the same set of structured questionnaire. The second year also involved a self-perceived efficacy (or productivity) index and a completion index that were coordinated by the students themselves. Individual ratings were tracked using a likert scale (1-7) and a percentage estimate that would set the current completion expectancy by the group. Both EM and OP applied this index. To track progression status in-between the semester's last two gates EM data have been singled out; 103 responses distributed at 12 occasions.

For the structured questionnaire detailed descriptions and explanations were provided in person each time data were collected. The questions targeted the efficacy matrix so that explanations were given for each compartment, and corresponding to elements of concern (i.e. P, the project group, C, the course and course admin, and F, firm). To achieve greater depth, an open-ended motivational question was used to better understand the reasons for the respondents' beliefs. Whereas year one involved two separate group sessions which put attention on the three included elements year two had this in common plus two self-regulated internal index that automatically draw attention to critical discrepancies. Data that indicated shifts from both individual and group level could be tracked which purposely provided several course analysis features to work with.
For the purpose of this study, student efficacy levels relate to a categorized mode that characterizes either a supportive or non-supportive environment. This is based on student overall interaction and relationship. In either of the two environments, students registered their self-efficacy level (high or low) in correspondence to whether the partnering element indicated a perceived value or not. In a combined two-by-two matrix, eight activity-labelled compartments were used, which addressed many of the similarities with the original definitions [1]. The compartments were identified and classified so that it would be possible to relate to three main motivational levers: value, efficacy expectancies, and the supportive nature of the environment. The results were captured in two combined two-by-two matrices where the decisive notion concerns an overall impression of a supportive or non-supportive environment.

4 RESULTS

Table 1 captures the categorized results (fall and spring) with the initial spring results in brackets. All indecisive in-between categorizations have been put in the nearest ascended compartment for providing an overview.

Table 1. Perceived student efficacy in relation to value and environmental elements

Year	Project group	Element	Environment is not supportive				Environment is supportive			
			Rejecting	*Hopeless*	*Evading*	*Defiant*	*Rejecting*	*Fragile*	*Evading*	*Motivated*
1	BF	Project group (P)						- (2)	1 (3)	13 (10)
		Course & c. admin. (C)				2 (1)		1 (4)	6 (4)	5 (6)
		Firm (F)	1 (-)	1 (-)	- (1)	2 (3)	1 (1)	1 (-)	2 (-)	6 (-)
1	LL	Project group (P)			1 (-)	- (1)	- (1)	6 (5)	1 (3)	6 (3)
		Project subgroup (P_x)								8 (-)
		Course & c. admin. (C)		- (5)	- (3)	4 (2)	4 (-)		5 (2)	1 (1)
		Firm (F)	1 (1)	6 (-)		1 (-)	- (3)	3 (1)	1 (2)	2 (-)
2	EM	Project group (P)						1	1	7
		Course & c. admin. (C)						1	1	7
		Firm (F)						1	1	7
2	OP	Project group (P)								10
		Course & c. admin. (C)				4		1		5
		Firm (F)				1			1	8

A *rejecting* characteristic relates to students who have little confidence in their abilities to successfully achieve a certain task. This is recognized in both supportive and non-supportive environments, and in consequence plays out a disengaging behaviour where absence or absent-mindedness is a frequent pattern. When students perceive tasks as doable yet unimportant due to indistinct guidance or instruction, they tend to favour an 'as-little-as-possible' approach to get by. This resembles what is addressed as an *evading* behaviour, and in relation to its given context a more positive side is acknowledged when the environment is considered supportive. Then the high motivational level to achieve outperforms the effects caused by unclear assignments, structure or guidance.
Students who perceive their environment as unsupportive yet see value attached to what they are set to accomplish show little motivation in relation to the given context that they are faced with. For this category of low efficacy and unsupportive environment, perceived expectancy for achieving a desirable task is insignificant and therefore of *hopeless* character. A supportive environment with a low efficacy level would characterize a *fragile* tendency where the desire to deliver is restrained due to inability to perform in line with requirement levels. In a high-performing context, the student perceives a 'no-matter-what' attitude towards the assignments at hand. Tasks are performed at high level since the value corresponds to an 'I-will-show-you' type of character described as *defiant*.

Students who are *motivated* perceive value propositions and efficacy levels at high levels with strong dedication to perform successfully in distinctive tasks as well as overall. This setting, independently of context, is characterized by harmony and fruitful engagement between interacting peers.

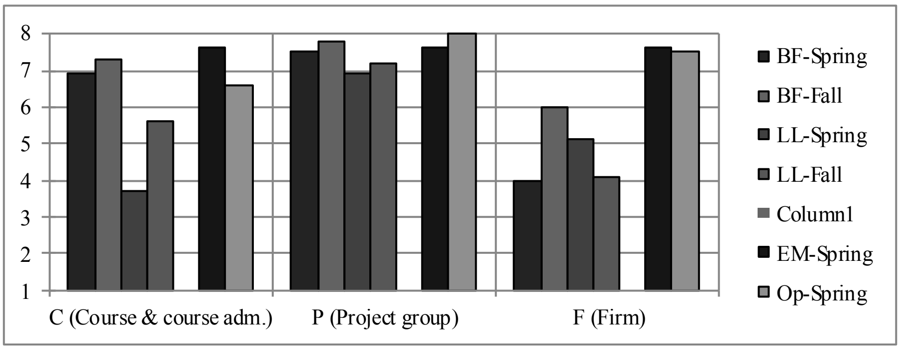

Figure 1. Mean values of motivational elements

The groups' mean value was derived by applying an index scale from 1-4 for the non-supportive environment and 5-8 for the supportive compartments (indexed in an ascending order with *rejecting* as 1 and *motivated* as 8). Any indecisive responses were given the mean of the two nearest indexed compartments (see Figure 2). Since the mean for LL should carry the weight of subgroup category (P_x), this has been taken into consideration in the above displayed chart with a refined project fall mean value (indexed to 7,2). It should be noted that in spring a mere third to a slight half of the interviewees showed any reason to split what took place outside the project group into anything else than course-related influences (C), as the firm (F) was a natural ingredient of the course to begin with. Those who did mark a separate indication in spring had experiences of interaction where distant influences still provided a reason for stating motivational effects. Obviously this changed as time elapsed, and in fall nearly everyone provided distinct data for each of these categories.

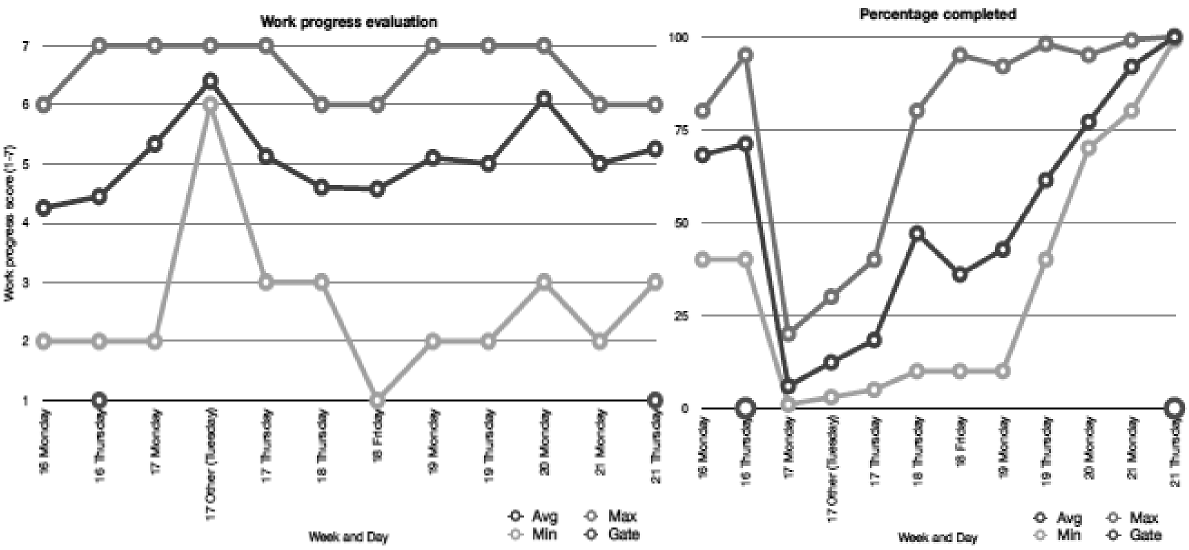

Figure 2. Mean values of perceived productivity and completion level

A productivity index consisting of team members self-perceived productivity (Figure 2). The compiled data projected a perceived a completion index of the project group in total as reflections aimed to interpret different status on current stage (i.e. EM's spring semester). This allowed both the project leaders and the team members to see the general status of the group's productivity (or more correctly the status of the working environment) in the group and familiarity in activities of importance ahead.

The index allowed early up-front discussion about what took place and re-evaluations of on-going priorities. The perceived index carried an implicit agenda that in case of alarming down-going trend would evoke discussion straight after compilation of the status so what the students related to as *'a corrective action'* could be put in place. The same line of actions applied when there were large differences in the answers. This indexed evaluation generated what was considered as *'clear goals to strive for; 100% completion and maximum productivity'*.

5 DISCUSSION

The four case results indicate that student motivation is strong throughout projects, but also that bad communication or shortage in valuable information can shift students' perspective towards lower-ranked categories. Since both course- (C) and firm- (F) related beliefs are dependent on a potential leverage of existing working knowledge, the expectancies must be matched by those individuals (coaches and firm representatives) who stand in direct contact with the students. The categorized model indicates inconsistencies between cases, although project input requirements were the same in both cases (year one). Year two showed a greater level of satisfaction cross all motivational levels. Quality of performance was met in all cases. The two projects from year one had excellent outputs that beyond the scope of the course resulted in; BF initiation of a patent application, and LL started to organize a systematic continuation to their core idea. Year two consisted of half-time much appreciated concept screenings.

In regard to the assessment process, coaches and faculty involved in the course of this character have a specific role. The course administration has to pre-plan and define an assessment scheme that includes the assessment task's relative weight for each task. Combining a dualistic role, project coaches take an active part in the assessment process, which contradicts what earlier research has put forward [9]. To avoid tendencies of dysfunction in a counterproductive coach-student relationship, overall student efficacy could possibly be enhanced if it were possible to detect the two roles that are combined in one individual: facilitating coach and course lecturer (responsible for assessment). One key for being able to move on to assessment is active involvement by the coach so that a value judgment of students is based on the learning objectives that the course aims for students to fulfil. The separation of roles is important as it leaves the coach free to encourage the dynamic development of the student project team processes [9]. Given the internal proximity of the project group, the influences that are derived from this important setting come as no surprise for achieving success in the project work. Similar to organizational studies, high self-efficacy has been found to strengthen both achievement culture and deep learning approaches [15]. This is especially emphasized as approximately half of the LL group addresses proximity and work intimacy as core elements in shaping their work efficacy. All project groups used designated subgroups and in addition to proximity these settings also tend to strengthen learning performance, integrated behaviour and fluidness [17].

In comparison to the outlined behaviour of subgroups, the impact of varying group size and social presence is attached with a several distinct features: greater emphasis to sensitivity, capability of listening, and social interaction as the group expands [18]. With group expansion follows the risk of detachment. What is gained through diversity and overall capacity might restrain emotional identification and sense of shared commitment, as this can be difficult to maintain over time and result in less satisfied students.

Implementing a sort of self-regulating index was designed to create an internal repository for continuous reflection on progression and perceived overall productivity. In comparison to first year's motivational tracking year two show a throttle effect towards the comfort zone of fully motivated students. Whether this could solely be traced back to the additional index is difficult to single out as there are of course a complex issue of other influencing factors. However, the indication push a dualistic proposition to be made: (a) further research is needed to in greater detail see how influencing elements of more external character can be promoted (i.e. coach facilitation and firm support); (b) course improvements need to be reinforced in order to pay more attention to the outline of requirement and delivery portfolio of what is expected by involved parties and key individuals. Based on the findings a combined effort would probably best meet what others consider important in regard to the work situations and requirements needed in today's engineering design projects [5][7]. This would also challenge the underestimated application of design elements in the curricula and question facilitation methods as well as assessment measures that have blossomed in recent years [6].

6 CONCLUDING REMARKS

This paper has tracked students' perceptions about their self-efficacy, originally inspired by the perceptual efficacy-framework of Ambrose et al [1]. Eight distinct compartments have been used, but proposed from an inverted mode, given a student perspective rather than a judgmental lecturer's point of view. The elements of concern have been to track differences in influencing beliefs and disbeliefs in regard to three modes of attention (project group, coach, and firm). In summary, students' perceptions of their efficacy level are determined by their proximity level and ease in meaningful communication between involved peers. The two groups showed variations in team composition and beliefs of how especially 'external' parties contributed to the respective group's overall performance and innovative output. Although output results were equally satisfactory between project groups, differences in perceived facilitation were seen. This suggests that further attention should be paid to requirement expectancies and to reassuring facilitation efforts for forthcoming projects. Hopefully, this present research effort will serve as an impetus to systematically test and implement theory-based development methods for continuous progress in evaluation efforts of students' efficacy and their learning environment.

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