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## The Collaborative Activities of Learning Design: Inserting Partnerships in Engineering and Technology Teaching with Novice Teachers

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### Abstract

*During the second year of their Education Master's degree, French novice teachers in Engineering or Design and Technology have to learn how to design tasks and activities to develop pupils' skills, capabilities, and knowledge. To achieve their tasks, they must follow the curricular requirements and train with their fellow students, along with their own teachers and tutors. In such a situation, do the novices assimilate collaborative learning practices when designing? What if they have to insert partnerships in their project-based learning design? How do they react and what do they do?*

*In order to answer these questions, research was conducted based on activity analyses of two classes of novice teachers (using questionnaires; interviews; activity tracks of artifacts and action research). The groups were observed in 2014, 2015, and 2016. The students were in multidisciplinary teams. Each team had to design a multi-technological project, to draw up specifications, and to adapt the project to include multidisciplinary pedagogical content for their own students. Each stage led to communication of the completed work.*

*The outcomes highlighted struggles within teams during the time that the novice teachers had to make up teams, carry out the project, and shape the pedagogical content. Team members also found a way to work together and to organize their activities. If the apprentices did not see the goal of the learning situation, they found it senseless and disputed the exercise. Those teams who tried to tamper with the required tasks needed the strongest guidance. Team members felt the need to link the projects to their actual learning and teaching field. Finally, participants achieved their goals of fostering PBL situations and fostering design partnerships.*

**Keywords:** *Collaborative learning design, Project-based learning, Design skills or abilities, Teamwork activity*

### Context of the Study: Training of Teachers in the Fields of Technology and Engineering Education

This paper examines in particular the training of French teachers in the STEM area (Strimel & Grubbs, 2016; Hacker et al., 2010) and more specifically in technology & engineering education. During the second year of their Education Master's degree, novice teachers in the fields of

industrial engineering, design and technology, learn to design tasks and activities to develop skills, abilities, and knowledge (Bødker, 2012; Ginestié, 2008; Sambu & Simiyu, 2016). To develop these tasks and activities, they have to follow curriculum requirements and to train with their fellow novice teachers, as well as their own teachers and tutors (Long & Carlo, 2013; Svinicki & Schallert, 2016). In this regard, the training involves collaboration where novice teachers from several educational fields learn to cooperate in a project-based learning (PBL) environment.

### **Theoretical Framework: Collaborative Design Activities**

Within PBL, students learn how to complete necessary planning tasks to gain results and realize their actions (Lawanto, 2013). Several researchers (De los Ríos, Cazorla, Dias-Puente, & Yague., 2010; David, 2008) highlight the impact of projects on learning. Helle, Tynjälä, and Olkinuora. (2006) underline that PBL is especially based on knowledge linked to different fields that can support designing and building of mental models. Knowledge also allows the understanding of a concept's complexity. PBL involves a multidisciplinary approach (Proulx, 2004) and potential partnerships (Aasland, 2010). It makes sense to collaborate in learning situations (Loperfido et al., 2011; Castéra, Sarapuu, & Clément, 2013).

In a literature review, several studies investigate the activity theory linking task and activity (Vygotsky, 1962; Leontiev, 1978; Engeström, 2005). This is a perspective that allows observation of what a teacher wants students to make, the tasks he/she suggests, what students actually make, and the activities they undertake.

To better understand the teaching-learning process in the field of technological education (Hérolde & Ginestié, 2009), there are some issues to discuss related to PBL. Do novices assimilate collaborative learning pedagogy into their practice? What if they have to insert partnerships into their PBL activities? How do they react and what do they do?

### **Study Methodology**

To address these questions, this study is based on activity analyses of two classes of novice teachers and on an action research project. The groups were observed in 2014-2015 (teams from T1A to T8A) and 2015-2016 (teams from T1B to T8B). All the students were mixed in multidisciplinary teams (Table 1).

Table 1: The teams' features

	2014-2015 (31 students)								2015-2016 (32 students)								
	T1A	T2A	T3A	T4A	T5A	T6A	T7A	T8A	T1B	T2B	T3B	T4B	T5B	T6B	T7B	T8B	
Team members	4	4	4	4	4	5	3	3	4	3	4	4	4	4	4	5	63
Product design																	6
Graphic design																	5
Fashion design																	1
Interior design																	3
Arts & cr. Stonecut																	1
Industrial engineering																	2
Civil engineering																	5
Mechanical engineering																	7
Electro-mechanic																	3
Electrical engineering																	2
Electronic engineering																	6
Energy engineering																	9
Lorry driver																	3
Boiler work																	1
Metalwork																	1
Stonework																	3
Automotive mainten.																	3
Automotive body																	1
Transport & logistics																	1

During the 2014-2015 year, they were more different design specialists and engineering specialists; the teams were set up by the teachers within the rules of multidisciplinary links (mixed disciplines to avoid a group with only one subject matter). During the 2015-2016 year, we observed a scattering of specialties, like mechanical works and an elimination of technology or arts and crafts. The teams were set up by the students themselves after an oral introduction of each student, and while the students discussed their teaching specialty they collectively organized the teams distribution on a white board.

During the first two semesters, each team had to design a multi-technological project (bioclimatic housing) to draw up specifications. The second two semesters were devoted to the transformation of the previous project into a fictitious adaptation including a focus on multidisciplinary pedagogical content. Each stage led to a presentation and to communication of the results of the completed work (Table 2).

Table 2: The multidisciplinary project and the different stages of the research

		2014-2015 – Semester 1 : 30h			2015-2016 – Semester 1 : 30h
(1)	14.09.23	Introduction Project presentation (slideshow) Teams' making up	(1)	15.10.09	Introduction Project presentation Teams' making up
(2)	14.10.14	Each team: discussions and negotiations Skills' table	(2)	15.10.09	Each team: discussions and negotiations Skills' table
(3)	14.11.26	Missing skills' table (requested expertise)	(3)	15.11.13	Missing skills' table (teams asked complementarities)
(4)	14.12.03	Project requirements (1st step: mind maps, plans, sketches, etc.)	(4)	15.11.13	Project requirements (1st step: mind maps, plans, sketches, etc.)
(5)	14.12.10	Project requirements (2 <sup>nd</sup> step)	(5)	15.12.04	Project requirements (2 <sup>nd</sup> step)
(6)	14.12.12	Project requirements (3 <sup>rd</sup> step)	(6)	15.12.04	Project requirements (3 <sup>rd</sup> step)
(7)	14.12.12	Project requirements (4 <sup>th</sup> step)	(7)	15.12.11	Project requirements (4 <sup>th</sup> step)
(8)	14.12.17	Syntheses and preparation of communications	(8)	15.12.11	Syntheses and preparation of communications
(9)	14.12.19	Syntheses and preparation of communications	(9)	15.12.18	Syntheses and preparation of communications
(10)	14.12.19	Syntheses and presentations of the teams' projects	(10)	15.12.18	Syntheses and presentations of the teams' projects
		Assessment			Assessment
					Interviews

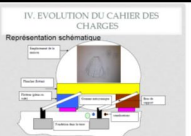
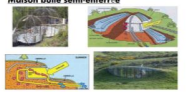



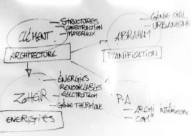

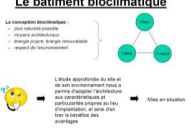
  

		2014-2015 – Semester 2 : 24h			2015-2016 – Semester 2 : 24h
(1)	15.01.23	Introduction Presentation of the 2 <sup>nd</sup> part's project (slideshow)	(1)	16.01.22	Introduction Presentation of the 2 <sup>nd</sup> part's project
(2)	15.01.23	Problem solving, representations and digital model	(2)	16.01.22	Problem solving, representations and digital model
(3)	15.01.27	Problem solving, representations and digital model	(3)	16.01.29	Problem solving, representations and digital model
(4)	15.01.28	Pedagogical project (designing, planning, drafting, etc.)	(4)	16.01.29	Pedagogical project (designing, planning, drafting, etc.)
(5)	15.01.30	Pedagogical project (designing, planning, drafting, etc.)	(5)	16.02.05	Pedagogical project (designing, planning, drafting, etc.)
(6)	15.01.30	Pedagogical project (designing, planning, drafting, etc.)	(6)	16.02.05	Pedagogical project (designing, planning, drafting, etc.)
(7)	15.02.03	Syntheses and preparation of communications	(7)	16.02.26	Syntheses and preparation of communications
(8)	15.02.04	Syntheses and presentations of teams' projects	(8)	16.02.26	Syntheses and presentations of the teams' projects
		Assessment			Assessment

The teachers documented their activities (using questionnaires; interviews; artifacts; slideshows; oral presentations; etc.) which illustrated several stages of the projects progress (Purcell & Gero, 1998). This approach followed The Buck Institute for Education (2012) recommendations that the realization of an individual report as well as a team report of the work

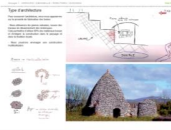



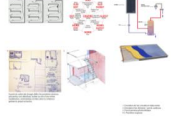



progress be compiled. This report can take various forms: logbook, portfolio, etc., allowing a highlighting of the differences between the requirements and the actual and realized tasks (Tables 3a and 3b).

Table 3a: Topics of the 14-15 teams, tools, and representations

	Stud.	Specialties	Topics	Representations' tools	Final slideshows (sample)	
2014-2015	T1a	S1-1a S1-2a S1-3a S1-4a	Interior design Civil engine. Electrical engineering Energy engine.	Fixed settlement which adapts itself to various extreme weather conditions	Text Table Schemes Mind map	
	T2a	S2-1a S2-2a S2-3a S2-4a	Interior design Fashion design Mechanical engineering Industrial engineer.	Design of a DIY 'bubble' house: in-ground bioclimatic housing	Text Table Pictures Schemes	
	T3a	S3-1a S3-2a S3-3a S3-4a	A. & C-Stonecut Industrial engineering Electro-mechanic Energy engineering	Settlement project for a Gabonese bioclimatic housing estate	Diagrams Pictures Schemes 3D CAD ISHIKAWA chart	
	T4a	S4-1a S4-2a S4-3a S4-4a	Product design Graphic design Civil engineer. Mechanical engineering	Bio'Cabanna® The bioclimatic, individual housing environment with moderate price	2012 Thermal regulations Pictures Schemes	
	T5a	S5-1a S5-2a S5-3a S5-4a	Lorry driver Electronic engineer. Product design Electro-mechanic	Minimum housing environment realized with worn containers	Table 'Rull chart' Diagram Schemes Pictures	
	T6a	S6-1a S6-2a S6-3a S6-4a S6-5a	Energy engineer. Civil engineer. Electro-mechanic Product design Mechanical engineering	'Bioclimatic Dar'	Functional diagram or 'flow chart' Drawings Several visuals Schemes Mind map Pictures Maps	
	T7a	S7-1a S7-2a S7-3a	Product design Electro-mechanic Electronic engineering	Innovative bioclimatic housing on the Frioul Island (Bay of Marseille)	Internet Diverse official documents Texts Handmade sketches Pictures Schemes Maps	
	T8a	S8-1a S8-2a S8-3a S8-4a	Mechanical engineering Electronic engineering Energy engineering	Building of a bioclimatic boarding school on the Aruba Island	Text Schemes Maps	

All the collected tracks cannot be exhibited in this paper (16 teams, 18 stages and several tracking versions that teams left on the university digital environment that have been downloaded). Some samples are displayed in Tables 3a and 3b.

Table 3b: Topics of the 15-16 teams, tools, and representations

	Stud.	Specialties	Topics	Representations' tools	Final slideshows (sample)	
2015-2016	T1b	S1-1b S1-2b S1-3b S1-4b	Mechanical engineering Boiler work Interior design Metal work	'Hab-borie' (French play on words with 'Hab' instead of habitat and 'Borie', a local farmhouse made with dry stones)	Internet Pictures Schemes Maps Diagram Mind maps 'Exploring all-around'	
	T2b	S2-1b S2-2b S2-3b	Graphic design Stonework Automotive mainten.	ECOLOGIS – Bio Habitat Optimum Wooden House for Tourism (BHOWHT) [in English]	'Google image' 'SketchUp' among several 3D CAD on line Handmade sketches Schemes 2D maps	
	T3b	S3-1b S3-2b S3-3b S3-4b	Product design Energy engineering Lorry driver Stonework	Design study of a bioclimatic rotating house with atypical shape	'SketchUp' 'Illustrator' Excel Handmade sketches Maps Pictures	
	T4b	S4-1b S4-2b S4-3b S4-4b	Graphic design 3 Energy engineering	Beyond the hills	'Board of trend' 'InDesign' Handmade sketches Mind maps 3D sketches and illustrations Schemes Pictures	
	T5b	S5-1b S5-2b S5-3b S5-4b	Product design Civil engineering Mechanical engineering Automotive maintenance	Development of a bioclimatic housing environment on the foundations of the Phocaeen city	Drawings Schemes Mind map 'Systemic drawings': GANTT & PERT charts InDesign Illustrator	
	T6b	S6-1b S6-2b S6-3b S6-4b	Graphic design Energy engineering Stonework Automotive body	Corsican individual bioclimatic housing	Drawings (Illustrator) Pictures Schemes Mind maps	
	T7b	S7-1b S7-2b S7-3b S7-4b	Graphic design Mechanical engineering Electrical engineering Automotive maintenance	'Biohousing' panorama	'Documents on paper' 2012 Thermal regulations InDesign PDF vs. PowerPoint Schemes with Word or Illustrator Handmade sketches'	
	T8b	S8-1b S8-2b S8-3b S8-4b S8-5b	Civil engineering 2 Electronic engineering Lorry driver Transport & logistics	Bioclimatic mobile home	Handmade sketches Schemes Mind map	

In addition to the above information, interviews (at the end of the first semesters) are analyzed to understand the differences between projects teams carried out and what they thought about inconsistencies between requirements and actual activities. Students are quoted using anonymous codes: for instance, the members of T1A are called S1-1a, S1-2a, S1-3a, and S1-4a. All members are quoted using their anonymous code and the number of their intervention during interviews (see Tables 4 to 7).

## Outcomes

### PBL as a Fight Å

#### - Å Against Several ĩBarriersDÅ

Teams struggled with several problems (outlined in Table 4). This fight led T5A to itemize some issues (S5-3a called it %barriers+, S5-4a, %discrepancies+, and S5-1a, %peculiar sensitivity+ or %falling apart+). First, they competed against the time allotted and finally found a way to buy time. For instance, T5B was competing with time to respect constraints, to be practical, pragmatic, %simple at most+ (S5-4b). T2B members felt they wasted time agreeing or compromising, debating, attempting to impose every point of view; they also found %things don't occur naturally+. T1B put it this way: (01. S1-1b) %We got to know each other well.+And (02. S1-1b): %We needed a long time to get to know each other.+

### - Å Against Í ClichésÍ Å

T5A necessarily carried out the project despite %experiences+, %preconceptions or preconceived notions+, %orientations.+ or %guidelines.+ It required team members to re-examine themselves, to take a new look at themselves. T1B found prior knowledge to be a %burden+, trying to break the deadlock. T4A (04. S4-1a) strongly %mournd+ the ambition of the first intentions or agendas.

### - Å and Against Í Other SubjectsÍ

Finally, teams struggled with other learners or teachers. T6A blamed the %non-significance+ of the teachers: they were not %of some use+. Furthermore, T6A & T7B challenged stakeholders, sponsors or backers because they seemed to be %off the project+. Consequently, T2B suggested the appointment of a project leader, who must:

- take responsibility (someone uses to be responsible);
- channel tasks and energy;
- save time;
- centralize action and information;
- %clear the air+ with team workers;
- help to choose wisely (making choices);
- build bridges (bonds, etc.);
- get what it takes to be a leader.

Table 4: PBL generates fighting behavior



PBL main features	Detailed PBL features	Teams statements or characteristics, quotes
Finding a way to work together, committing to the teamwork	Struggling behavior: competing with time or wasting energy	T1B called it a race against the clock; however, team members were aware that this race was a means for developing skills (13. S1-1b to 15. S1-2b quotes) T2A: the deadline especially during teamwork (worried S2-4a: 05, 06 & 07. S2-4a). T2B: wasting time seeking a project leader and expecting teachers would choose one on their behalf. T4B. S4-1b & S4-3b. They regret the uncertain length of the assigned tasks: %long or short time per tasks+(S4-1b); %at the beginning of the year, it was holidays and last week we had to work harsh; %last week, we really believed that we were going to lose hairō +(S4-3b). T7B. 02. S7-3b: tough to find the way to %create+, to %enhance creativity+, to %overstep the representation stages+and the problem solving. T7B. 13. S7-1b: fighting the noise during teamwork, seeking isolation to focus on the project and to product.
	Struggling behavior with %alichés+	T2B wanted to make the project anyway, but other team members gave up. T2B. S2-3b: %it's hard to lead a project.+ T3B. S3-4b and S3-3b had former representations and skills that prevented them from understanding the project and its design. Dialog with team mates aided. They especially opened their mind. They got out of the rut in which their former ideas blocked them. (To be reproduced in %mastering design+) T4A: designing is shaping before introducing technical considerations. T5B. 14. S5-2b: %I sure got stuck in the head+
	Struggling behavior with others (teachers, other students or stakeholders)	T1B: how to unveil the way T1B carried out the project getting teamwork under control. T1B. 02. S1-3b: %I don't know exactly what to do but we don't care until it's of use to us!+ T1B. 30. S1-1b: %We asked ourselves whether it was on purpose or whether it was an observation stage.+ T1B: fighting against unsettled stakeholders while acknowledging as novice teachers they behave identically with their own students. T2B. Applied arts teacher fought against technical aspects that the engineering part of the team enhanced. Inside T2B team, things did not naturally occur. T7A. 16. S7-1a: %Me too, this is an ethic point. If that isn't good enough, I'm off the project.+ T7B. 13. S7-2b: stakeholders did not know the real requirementsō

### Working Together with a Clear or an Unclear GoalLack of Visibility

Despite unclear requirements called by several teams: %lack of visibility+ or %senseless+ students found a way to work together (Table 5 for other details). T3B had no understanding, asking: %What is the goal?+ T3B needed more visibility to understand how to progress and how the project would be assessed. T1B stated (04. S1-1b): %So, where did we put the slider? [ō ] it was the point that took up most of our time.+

### Rumors but Agreement

T4B noticed fake information, rumors, gossip, and whispers, instead of strong guidelines, and specifically added: %It was a grapevine+(15. S4-1b). On the same point, T1B decided the issue: %After a while, we stopped to look at the others+(01. S1-3b). T6A must have considered several team adjustments, synchronizing and upgrading each other step by step. It allowed them to face differences in skills with an open mind and to say they %got enough to realize something beautiful and innovative+(01. S6-5a). While the make-up of the team was messy, its asset was

human contact+ (02. S6-1a). This kind of relationship was based on consensual motivations (02. S6-3a).

### **-Tampering with Tasks**

They faulted tasks they found senseless or contradictory. T4A disputed a prerequisite when stakeholders questioned it too and tried to negotiate and reconsider the project. T7B fought against exercise (02. S7-2b), enhancing skillsqaffinities rather than real skills and mixing up knowledge, skill, and capability.

### **-Requesting Stronger Guidance While Being (Novice) Teachers**

T2B regretted the lack of accurate guidance and therefore demanded the appointment of a project leader (S2-1b & S2-3b). Another student claimed: %appreciate when someone tells me you do thatqor you do thisqneed a frame, guidelines+ (15. S3-3b). From the same team: %We don't know where to move, sometimes+(15. S3-2b), or: %But, we'll do it, anyway (laughs)+(16. S3-3b). T7A did not understand the differences between the knowledge the topic required and the written requirements. They found it paradoxical and felt abandoned and a little bit lost. T7B questioned what they have to do exactly. They raised a contradiction between concise constraints and unclear goals. They also did not understand the interest of skillsqpresentation by all students, thinking this was a %andom setting up+. To conclude, T4B found it tough to work without strong guidance or without omnipresent teachers. The team also recognized that it is a ridiculous situation to be managed like pupils while they are student-teachers.

Table 5: PBL encourages collaboration

PBL main features	Detailed PBL features	Teams statements or characteristics, quotes
Working together (within and between the teams)	Finding it senseless	T2A. 02. S2-2a.: %We couldn't determine our skills because we didn't know what the use was. At least it helped us a little. And we also used our representations.+
	Working with or without	T5A was remade because of the arrival of a new member: it improved teamwork while they fought against constraints they added themselves. According to T7B, all teams had difficulties to %solve the problem+ in the prescribed time (or within the allotted time).
	Tampering with required tasks (solutions before specification)	T1B. 08. S1-2b. Team members worked outside regular hours although requirements said teams must work during class. T2B. 12. S2-2b. Filling the daily form to bring the content into line with the teachers'idea and not to the students'design; however, they got the goal and achieve the task. According to media and other clichés, T5B initially thought of a hidden country cottage without environmental impact. But it decided to design a townhouse and team members found it a pleasure and a challenge.
	Demanding stronger guidance (to know what exactly the requirements are, or to appoint a project leader)	T1B compared the understanding of teachers'requirements with other teams. It seemed they did not get same information. They tried to gather some hints. T2A. Because of renewed requirements, T2A found it tough to seek direction, anticipate solutions, and so on. T2A. Without disputing requirements, T2A describes the efficiency of learning situation contributing to focus on the real problem. T2B. Lack of guidance was perceived as a deliberate decision to compel team members to step back. T4A. According to S4-2a, some stakeholders did not introduce themselves and caused confusion. With a clear understanding of the stakeholders'role, students may have been able to question more precisely. 12. S4-1b: %Teachers can't be everywhere, but sometimes, it's difficult to wait [ō ] if we have a claim.+ 13. S4-2b: %ight or twenty-two slides? Everybody gets desperateō + 14. S4-2b: %t looks a little academic and it seems ridiculous to manage people who are novice teachers but, nevertheless, I think it's just as well, sometimes, to write guidelines on the blackboardō +

## How to use Teaching Matters or Former Expertise

### Relying on what Novices Already Know

Teams mainly asked to bind the projects to their actual learning and teaching field (Table 6). T4B made self-presentations to determine or identify their own skills. T2A stated it so: %we have different ideas because we're working more in terms of representations+(26. S2-1a); %that's the work method you can find in an industry engineering department, for instance+(15. S2-4a). T5B highlighted and managed former representations' methods like: drawings . Gantt chart . Excel Tables, etc. T2B involved everyone, seeking compromise on the project illustrated by a T5A quote: %Nobody forces anybody+(13. S5-3a). T4A emphasized a debate with other specialists that allowed for a reappraisal.

### Managing Discovered Skills

T5B managed skills to synthesize, to summarize, to simplify, to be consistent. T5A thought teaching is a way to engage in collaborative work such as in the voluntary sector or collective

organizations or club management. A T2B member may have planned a multidisciplinary project in high school (24 & 26. S2-3b): it seemed easier because every committed teacher knew what to do. S2-3b expected a learning project, one that it called an *instructional sequence* that involved a training progression.

### Shaping Pedagogical Contexts

T1B imagined a learning situation to provide practice (26. S1-1b). T3B requested the same learning situation they organized with their own students. T5B showed pupils ways of designing (31. S5-2b): diagnostics development; assignments; specification; skills sharing; etc.

Table 6: PBL enhances dialog and collaborative work

PBL main features	Detailed PBL features	Teams statements or characteristics, quotes
Binding projects to the teaching fields and jobs	Acquiring knowledge linked to different fields	T1B. 20. S1-3b: struggling with internal stakeholders and their unclear specifications, like in his/her teaching job.
		T5A. Sharing languages to communicate easily with a common language; sharing objectives after long debates; learning to communicate and to understand interpretations of each expert making up the team.
		T6A. 07. S6-5a learned during an industry internship that specifications could have been reshaped.
	Managing former collaborative skills	T2B made an internal agreement to distribute the different tasks according to inner skills.
T2B. 01. S2-3b: <i>Everyone contributed.</i>		
T2B added members skills and did not balance.		
T7A first defined an <i>acting location</i> to set up its project.		
Managing discovered collaborative skills	T7B. 07. S7-1b: <i>We got different tools, so we had to explain things to be understood.</i>	
	T4A. Managing collaborative work and skills without taking the risk: how to follow the rules for fear of losing themselves. A kind of discovering of new collaborative abilities.	
Shaping pedagogical contents	T1B. Avoiding technical things (standards, charts, <i>stuff</i> ) to communicate to a diverse, heterogeneous audience (06. S1-3b).	
	T3B. S3-3b thought of an instructional project with models and mockups, while S3-2B asked how to transpose their teamwork in a real learning situation.	
	T4B. S4-2b suggested a transposition in a learning situation requiring a focus on teamwork skills and not on the topic.	

### Fostering PBL Situations

#### Organizing Activities to Achieve Project and Learning Design

This dialog between three T1B members illustrates the idea (Table 7). T4A itemized carrying out the mission: visualizing the project; finding technical situations; seeking environmental information; asking some other experts. T5B (S5-1b) had a precise definition of the learning situation, looking at how to:

- React in a team in which members deliberately came from different fields.

Look at how people could previously project in an unexpected way.

Look at how balances could be carried out. T5B also precisely reported a concerns and affordances related to collaborative design activity:

- issues with illegible, unreadable handmade drawings (sketches, drafts with erasures, deletions);
- back-talks and corrections;
- use of vector drawings applications (Illustrator and InDesign);
- debates about efficient use of paper or PC (easier to practice with four learners around paper than in front of a screen);
- sketches as efficient starters, fast enablers of exchanges, dialog;
- go and return+between handmade drawings and digital design (iterative process);
- enhancing of communication (empowering channels).

### **Planning Tasks and Activities**

T5B resolved several unexpected skills or irrelevant abilities to answer the questions teachers asked. They harmonized each member's commitment or willingness to build something. T5B completed and achieved by focusing and re-focusing on the project+(03. S5-1b). They coped with it, anyway+(05. S5-1b).

### **Fostering Partnership and Design**

S3-4b and S3-3b (T3B) had prior conceptions and skills that prevented them from understanding the project and its design. Dialog with teammates aided. This group in particular, especially opened their minds. They got out of the rut in which their former ideas blocked them. A team member said: "Every time someone gets a job done, everybody gives the opinion on it too." T3B got the other teams to palliate shortcomings or misunderstandings and to bring new solutions. Moreover, requirements were distinctly understood from team to team. It needed dialog away from teachers in order to unveil the actual requirements. Together they chose a pleasant+and unusual+or non-typical+path to carry out a project.

### **Knowledge of Designing and Building Mental Models**

T2B mixed the technological fields to understand that they were missing something+. T4A members re-examined or challenged themselves, reassessed their ways, and broke away+ from former representations or opinions as said in this dialog:

- 03. S4-4a: "So, abstracting the issue, so, opening it +"
- 06. S4-1a. Sharing a picture all the team members got and so, opening it to let other people go inside.

To conclude, T5B members admitted:

- 03. S5-2b: "Forging an assignment.+"
- 15. S5-4b: "We showed what was fit to be seen.+"

Table 7: PBL fosters partnership

PBL main features	Detailed PBL features	Teams statements or characteristics, quotes
Carrying out the project within a PBL situation	Organizing activities to achieve project and learning design	<p>T1B: they isolate themselves from their peers to focus on their work of making a video projection to gather data and share the tasks they identify.</p> <p>- 22. S1-3b: %We were lost.+ - 13. S1-4b: %We made our own decisions and we figured it was time to decide and to make it this way.+ - 06. S1-1b: %Finally, there are different sensibilities. Everyone learns from each other. [ō ] Thus, I learned to create better lessons for the other specialties.+</p> <hr/> <p>T2B. 02. S2-1b: %In a way, we tried to get the best qualities of each other to achieve the goal we were assigned.+</p> <hr/> <p>Despite the lack of project leader and time, T2B carried out the project, outlining representations as tools to be understood by a large audience. T2B also gathered all its members.</p> <hr/> <p>T7A had a moment of hesitation (an %awkward moment+) and, so, kept its work about basic specification to be available to design.</p>
	Planning tasks and activities	<p>T3B. S3-1b: %Choosing without time to design+.</p> <hr/> <p>T5B. Discussions about the project to compare vocational or specific views on specifications. All members evolved and changed their definition of specifications.</p> <hr/> <p>T7B dispatched the tasks according to each skill set.</p>
	Fostering partnership and design	<p>T4A. S4-1a needed a specialist on project management.</p> <hr/> <p>T7B. 01. S7-2b explained the discussing and brainstorming the team conducted in order to choose the %good idea+; to scaffold and underpin it, to %unfortunately+make compromises. T7B. 06. S7-3b admitted all issues were %creativity engines+ It looked like a dynamic process.</p>
	Knowledge to designing and to building mental models	<p>T2B. 14. S2-1b: %On my own behalf, I felt a little bit dumped because it's not my job. So, finally, I succeed to follow suit, quickly. And I think we completed some interesting things with each other.+</p> <hr/> <p>T2B. A learning situation; teachers moved toward deep thought and things shaping.</p> <hr/> <p>T6A. 12. S6-1a learned what design is even though he already worked in an industry engineering department. All team members experienced collaborative work.</p>

## Discussion

From one year to the next, student teams did not react similarly, although the requirements and the sequence chronology were similar (with a few improvements and shifts). In 2014-2015, novice teachers, in addition to other designers, re-examined themselves. Most of them experimented with collaborative work during their studies or in a former job, internship, or teaching. They projected less pedagogical content than the following year.

In 2015-2016, team members were stressed by the requirements. Consequently, they demanded stronger guidance, continuously looked at the work of the other teams, compared the methods they chose, and checked interpretations of the specification. However, %after a while+, they %stopped to look at the others+ (T1b), and made their %own sweet way without asking [themselves] too many questions+.

Gathering all the products the teams designed, this ongoing action research highlights the necessity of a common world in which dialog between several experts needs time because teamwork helps to develop a constructive work dimension (discussions about barriers to cross, building teams, etc.) rather than a productive dimension (e.g., no time to produce).

## Conclusion

This paper presented a first step into analyzed data of a PBL situation with 16 teams of students+teachers in engineering, design, and technology fields. At this stage, first outcomes allow an understanding of the generation process. Meanwhile, teams of novice teachers do not look like engineers+teams or designers+teams, but they worked like them, especially when they sought to overcome the %discrepancies+with diverse strategies they could not quickly or easily find (how to share the same goal). In this way, novice teachers demanded more supervision. Following on this process, they produced pedagogical content that will be analyzed in a further paper.

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