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Toward Project-based Learning and Team Formation in Open Learning Environments

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Abstract: Open Learning Environments, MOOCs, as well as Social Learning Networks, embody a new approach to learning. Although both emphasise interactive participation, somewhat surprisingly, they do not readily support bond creating and motivating collaborative learning opportunities. Providing project-based learning and team formation services in Open Learning Environment can overcome these shortcomings. The differences between Open Learning Environments and formal learning settings, in particular with respect to scale and the amount and types of data available on the learners, suggest the development of automated services for the initiation of project-based learning and team formation. Based on current theory on project-based learning and team formation, a team formation process model is presented for the initiation of projects and team formation. The data it uses is classified into the categories "knowledge", "personality" and "preferences". By varying the required levels of inter-member fit on knowledge and personality, the team formation process can favour different teamwork outcomes, such as facilitating learning, creative problem solving or enhancing productivity. The approach receives support from a field survey. The survey also revealed that in every-day teaching practice in project-based learning settings team formation theory is little used and that project team formation is often left to learner self-selection. Furthermore, it shows that the data classification we present is valued differently in literature than in daily practice. The opportunity to favour different team outcomes is highly appreciated, in particular with respect to facilitating learning. The conclusions demonstrate that overall support is gained for the suggested approach to project-based learning and team formation and the development of a concomitant automated service.

Keywords: Open Learning Environment, MOOC, Social Learning Network, Project-based learning, Project team formation, Team formation service
Categories: L.3.6, L.6.0, L.6.1, L.6.2

1 Introduction

More and more, learning takes place in open learning environments (OLEs) with geographically dispersed learners, such as Open Online Courses (OOCs) and their large-scale variants called MOOCs (Massive Open Online Courses). However, recent reports reveal that learning in MOOCs has its drawbacks: Dropout rates are massive, while the intended collaboration between learners is limited [Daniel 2012, Edinburgh University 2013]. The following factors may contribute to this:

- Learners overestimating their abilities (learners subscribing who would otherwise not be allowed to do the course on the particular level),
- The novelty of the offerings (attracting subscribers who are mainly interested in the workings of the OOC), or
- Learners finding out during the course that they are not willing or able to commit to the course regime (learners and others subscribing who are not sufficiently motivated to follow through the course).

However, we argue that the dropout and limited collaboration might also – at least partly – be explained by a lack of motivating learning opportunities based on well-founded pedagogics. When OOCs were first suggested by Downes [Downes 2006] and Siemens [Siemens 2004], they were based on the pedagogical vantage point of networked learning ("connectivism" is the term they coined to label these OOC settings), emphasizing learner self-direction and contribution. These ideas in themselves were not new, as e.g., work by Westera [Westera 1998], Wellman et al. [Wellman, Salaff, Dimitrova, Garton, Gulia and Haythornthwaite 1996], and Steeples and Jones [Steeples and Jones 2002] already described learning settings based on such principles. But perhaps due to the success of MOOCs and the burden they place on teaching staff when supporting such large-scale settings, this vantage point has been abandoned. Current MOOCs have become learning environments primarily based on behaviouristic pedagogy, in contrast with the OOCs envisioned by Downes and Siemens [Daniel 2012]. However, an OLE may also be too open: Learners' self-direction suggests that learners are able to identify their learning needs and the resources required to fulfil these needs and have strategies to learn and assess their progress towards these needs. In such cases OOCs could consider to offer assistance, by providing e.g., an entry test or a trial lesson, enabling the learners to better estimate their abilities with regard to what the OOC requires of them.

In an effort to re-establish the earlier networked learning foundations in OOC-based learning, we argue that the results from earlier and on-going research into the development of Social Learning Networks [Koper and Sloep 2002] can help understand the problems OOC learners and teachers face and can help to overcome motivational and dropout problems. These Social Learning Networks (SLNs) are defined as computer-supported, partially overlapping ensembles of *communities* of learners, in which support is provided for learning, sharing and developing knowledge, with the help of technology [Sloep et al. 2011]. SLNs aim at supporting potentially large groups of distributed self-directed learners who can work and learn collaboratively in projects (for e.g., innovation, research or assignments), set up working groups, communities, discussions or conferences to acquire competences [Koper 2009, Sloep and Berlanga 2011].

Two important observations about SLN learners' characteristics should be kept in mind:

1) That groups of self-directed learners initially have only weak links between them: The learners have limited knowledge about other learners [Jones, Ferreday and Hodgson 2008], and
2) That these learners can suffer from a lack in continuous self-motivation [Kim 2009].

Therefore research into Social Learning Networks design focussed on various support methods to improve both the coherence between learners (in order to build up the network between learners) and the motivation of the learners (in order to retain learners and to improve learning outcomes). Designs have been developed, ranging from recommending resources to each other [Drachsler, Hummel and Koper 2008], doing small activities together to get acquainted based on peer-support [Van Rosmalen et al. 2008], to learning how to present yourself in the network to promote trust [Rusman, Van Bruggen, Sloep, Valcke and Koper 2012]. These designs, and others, have been successfully tested within the context of Social Learning Networks and are likely also applicable to MOOCS.

We suggest that performing collaborative learning activities together is another excellent opportunity to motivate learners and to change and anchor (loose) relationships (See Textbox 1 for an example of how we envision this to happen in OLEs). So far, however, this opportunity has only rarely been explored in SLNs and MOOCS. Two well-known collaborative learning strategies are problem-based learning and project-based learning. Both support collaboration, but the former primarily focuses on supporting the collaborative process (in particular on problem solving strategies), while the latter primarily focuses on supporting the creation of a collaborative product. Most learners, especially lifelong learners, will already have experience in collaborating in projects as current education habitually provides these settings, whereas problem-based learning is less common. Additionally, problem-based learning, with its focus on acquiring problem solving strategies, may require different criteria for team formation. In this article we will therefore concentrate on project-based learning.

Project-based learning (PBL) should fit very well to the issues outlined above. Literature lists several benefits to be had from PBL. They include improving the learners' motivation, so that learners are more inclined to deal with hard, complex problems and spend more time studying [Johnson, Johnson, Stanne and Garibaldi 1990, Marin-Garcia and Lloret 2008). Other benefits of PBL are found in the blend of learning and working and the realistic (inter-professional) learning experience [Springer, Stanne and Donovan 1999, Felder, Felder and Dietz 1999], which prepares learners for real life working conditions. Collaborative learning, when compared to individual learning, is also shown to lead to an increase in learning outcomes [Hsiung 2010].

Therefore introducing PBL opportunities into OLEs, such as SLNs and MOOCS, would address the points mentioned above: It builds links between learners that learn together (which might enable the transformation of these loosely coupled learners into e.g., communities of practise (COPs) [(Lave and Wenger 1991, Sloep 2013], and it provides motivating learning settings. It will introduce a well-known learning paradigm which fits into the original networked learning pedagogies for OLEs. As do

the other support designs discussed above, supporting PBL has the potential to contribute to solving part of the problems outlined.

May 2013: Emma recently started her new job at the microelectronics department. For the first two months her main task was to strengthen her knowledge in this domain. She decided to follow a highly recommended MOOC course because this MOOC, besides the regular lectures and other materials, also contained a 4-week collaborative project work period. She fondly remembered studying in projects during her initial education and the relationships they helped to build. In the MOOC, the projects were presented on a "project wall", offering the opportunity to apply. The project assignments varied between standard projects proposed by the MOOC, to projects defined by peer-learners, companies and research institutes. The application process followed an automated, open procedure to select the best applicants. Emma selected an interdisciplinary project on biochip design, which was to be performed by at least 4 persons. She could apply by sending in a brief summary of around 100 words on her knowledge and skills with regard to a list of topics address by the project, by filling out her preferences in a profile (on her preferred collaboration language, availability schedule, etc.) and by taking a personality test. Emma decided to give it a try and went through the intake procedure. A few days later she received an invitation to participate in the project and contacted her fellow project members to make arrangements.

Textbox 1: Project-based learning in an OLE

However well PBL seems to fit the networked learning educational aims of OLEs, the introduction of PBL in an OLE is *not* a straightforward operation. This can become clear from the following comparison between the possibilities of setting up project-based learning in formal, teacher-led educational settings versus doing so in OLEs.

In formal education:

- A teacher likely will have the task to define projects that fit inside the formal educational curriculum,
- A teacher will be responsible for the formation of the project teams,
- A teacher can rely on personal knowledge about the learners and/or data sources (grades, prior courses) from e.g., a Learning Management System (LMS) to form teams,
- The learners learn in relatively small cohorts. These cohorts mostly show coherence with respect to place, time and collective progress in the curriculum and commit themselves to the formal educational regime.

In OLE learning settings, due to issues of scale and openness:

- A teacher will not be able to provide a sufficient amount of project proposals to accommodate all learners,

- A teacher will not be able to effectively form teams,
- Participation in an OLE does not amount to the same data gathered from the learner as in a formal educational setting. Therefore the data required to form effective teams are most likely not available. Furthermore, as learners can and do drop out of OLEs, the data that is available will often be incomplete or erroneous,
- Learners in OLEs can have a wide variety of knowledge backgrounds,
- Learners in OLEs originate from over the world, carrying with them characteristics such as language preferences, time zones, agendas, etc.

We therefore suggest to design an *automated project-based learning and team formation support service* which takes into account the OLE learning settings.

Since there is ample research on team formation principles for staffing projects from multiple disciplines (from education, human resource management, etc.), we take that research as a starting point for the introduction of PBL and team formation suitable for OLEs. The design will need to be able to accommodate:

- The number of learners,
- The burden on teachers for providing projects and forming teams in OLE settings,
- The characteristics of the OLE learners,
- The learners' probable lack of knowledge of effective team formation.

To address these issues, the design starts from the considerations that in OLE-based settings: 1) learners should be enabled to start projects, so teachers don't have to define them; 2) that these projects are not necessarily positioned in well-defined curricula; 3) that projects are staffed by learners who can have a wide variety of knowledge backgrounds and project-related preferences; 4) that for an automated team formation process to be effective it should be based on current theory and practise (thereby mimicking team formation expertise as embodied in teachers).

Therefore, the main research question we address in this article is: *Which principles and processes underlie the introduction of project-based learning and team formation in open learning environments, given the specific characteristics of open learning environments and their users?*

This article is divided into 8 sections. After this introductory section 1, in section 2 we introduce team formation theory for project-based learning. It addresses which data should be considered when forming teams and how rules could be applied during team formation to form teams fit for a specific task. In section 3 we present a team formation process model, which we derived from the theory examined. In section 4 we describe the method we used to corroborate the team formation model with professional practitioners in project-based learning and team formation. Section 5 presents the results obtained. In section 6 we discuss these results, while section 7 draws conclusions. Section 8 presents directions for future research.

2 Team formation theory for project-based learning

In formal educational settings, organising PBL includes the definition of a project task and the formation of a project team around that task. Oakley, Felder, Brent & Elhajj [Oakley, Felder, Brent and Elhajj 2004], Obaya [Obaya 1999] found that to form effective teams team formation expertise is required, thus discouraging unsupervised or self-selection-based team formation. When team formation is not based on team formation expertise, its results can be subject to pitfalls. Self-selection, for example, can affect the quality of the project outcome through: a) Team formation around pre-existing friendships, which hampers the exchange of different ideas; b) The tendency of learners with similar abilities to flock together, so strong and weak learners do not mix, thus limiting interactions and preventing weaker learners to learn how stronger learners would tackle problems. The stronger learners would also not benefit from the possibilities to teach their peers, and c) The problems under-represented minorities can experience. For example a woman in computer science can become isolated in a team, which can lead to non-participation or adoption of a passive role, like the team's secretary. A non-native speaker of some language might become excluded from discussions [Oakley et al. 2004].

These findings are supported by an earlier study by Fiechtner and Davis [Fiechtner and Davis 1985], which reported that out of 155 students two-thirds indicated that their worst group work experiences were with self-selected groups, while their best experiences were with teams formed by their teachers.

As we need to define projects and form teams to execute them, we next need to investigate which data are required to perform this process.

2.1 Data to take into account when setting up PBL and team formation

Felder and Brent [Felder and Brent 2007] hold, that for a teacher to form effective teams, the teacher requires data about the prospective team members and the project task. Research by Graf and Bekele, [Graf and Bekele 2006], Martín and Paredes [Martín and Paredes 2004], Wilkinson and Fung [Wilkinson and Fung 2002], Slavin [Slavin 1989] provides an overview as to which data should be taken into account when PBL is set up and teams are formed. We present these data in two categories:

a) Knowledge related data: The curriculum area in which the project task will be positioned; the project task, and its characteristics (such as collaboration language, duration and suggested team size) and the individual learner's abilities and prior learner achievements.

b) Personality related data: The individual learner's personality traits, and motivational orientation.

Depending on the characteristics of the OLE learners, we might have different ways to gather these data: When the learners are students enrolled at the educational institution offering the OLE, a large part of the data needed might be mined from the educational administrative systems. However, when the OLE-based course primarily attracts external learners these data will have to be gathered from the learners themselves directly or by asking for access, if available, to e.g., their e-portfolio [Penalvo et al. 2012].

Next, in order to be able to suggest ways to fit learners to projects, we examine team formation principles.

2.2 Fitting learners to a project, each other and possible team work outcomes

Judge and Ferris [Judge and Ferris 1992] and Kristof [Kristof 1996] consider the process of project team formation to be an optimisation process for finding an optimal fit between a person and team. Werbel and Johnson [Werbel and Johnson 2001] and Werbel and Gilliland [Werbel and Gilliland 1999] qualify the concept of fit as containing complementary elements (providing to the team something which other members lack) in some respects, while containing supplementary elements (sharing something with other members) in other respects. In an example aimed at improving learning in a team, Werbel and Johnson [Werbel and Johnson 2001] suggest a rule to form a team for that purpose: A team formed to foster learning should consist of team members that provide complementary fit in knowledge background, but who at the same time show supplementary fit in personality. Teams formed in this way allow their members to learn from each other's different knowledge backgrounds while the team shows high levels of cohesiveness and faster decision making [Muchinsky and Monahan 1987, Kristof, 1996].

Vigotsky [Vigotsky 1978] provides a quantifier for differences in knowledge backgrounds: They should be within the zone of proximal development for learners to be bridgeable. As for the personality aspect, Goldberg and Jackson et al. [Goldberg 1990, Jackson et al. 2010] consider the personality aspect "conscientiousness" (which measures learner carefulness, thoroughness, sense of responsibility, level of organization, preparedness, inclination to work hard, orientation on achievement, and perseverance) to be the predominant indicator for future success in project work.

However, teamwork can have multiple aims. If the teamwork aim is e.g., to provide a creative solution for a problem, then too much complementary fit in knowledge could lead to a loss of creativity [West 1997]. This suggests that multiple team formation rules can be designed, depending on the envisioned outcome of the project work.

3 A project-based learning and team formation process model

In the introduction we set out with the challenge how to provide OLE-learners with motivating, network-strengthening collaborative learning opportunities. We argued that providing support for project-based learning and team formation could answer this question. In this section we therefore introduce a generic process model for the initiation of project-based learning and team formation. In order to be widely applicable, this process model aims to fit into both OLE and formal educational settings. The process model takes into account the team formation theory introduced in the previous section. We first categorise the data to be taken into account when setting up tasks and forming team, as introduced in section 2.1, and then argue that for team formation for OLE-learners, a third category of data is of utmost relevance. Next, we describe how PBL and team formation can be initiated and then we present the process model we derived.

3.1 Process model data categories

In section 2.1, we introduced two categories of data needed to set up project-based learning and perform the project team formation. These were:

a) Knowledge-related data

b) Personality-related data

However, learners in OLEs can carry with them characteristics that distinguish them from regular curriculum-bound learners (such as their geographical distribution, mastering different languages, having jobs and different time schedules, families, etc. [Fetter, Berlanga and Sloep 2010]. These characteristics can pose practical problems in collaborations, even prohibiting collaboration. So for them, obviously a third category of data is relevant to take into account when forming teams:

c) Preferences-related data (such as preferred collaboration language, availability, time zone, etc.).

3.2 The project based learning and team formation process model

In our view, the initiation of PBL and team formation starts with the definition of a project related to (a part of) a knowledge domain (such as a curriculum, a topic in a SLN, or the MOOC topic). Its characteristics are defined (such as preferred duration, team size, etc.). Depending on the level of openness of the OLE, these can be defined by the learner, by the teacher, or partly by both. In order to ensure the appropriateness of the project definition in relation to the domain, a level of fit between the project definition and the domain can be determined. In our related work [Spoelstra, Van Rosmalen, Van de Vrie, Obreza, Sloep 2013] we suggest that language technologies can help to assess the overlap between the suggested project definition and the OLE domain. Alternatively, the learners themselves can assist in controlling the quality. PeerScholar, a system for assessing writing assignments, shows that peer assessment can be a valid quality control alternative in large classes [Paré and Joordens, 2008]. Furthermore, a framework with clear rubrics could guide both the students who propose or execute a project and the peers who assess the quality of the project definition or (once the project is started) the project's (intermediate) results.

In the next step in the process model, the learner's knowledge, personality and preferences are assessed. The outcomes of these assessments are compared with the requirements the project and characteristics set forth, and the other members' assessments outcomes. This then leads to a measure of fit between the project and the prospective team members. The team formation process ends with a suggestion for a project team when one set of project-suitable members can be found that shows optimum fit (the best fit team solution), or when all members are dispersed over teams (the best possible average solution). Figure 1 depicts the process model.

The proposed process model introduces an important feature: By providing the ability to qualify what should be considered a good fit between a project and its members (see section 2.2), it becomes feasible to direct the project formation process outcome towards forming teams that are specifically suited for a particular project aim.

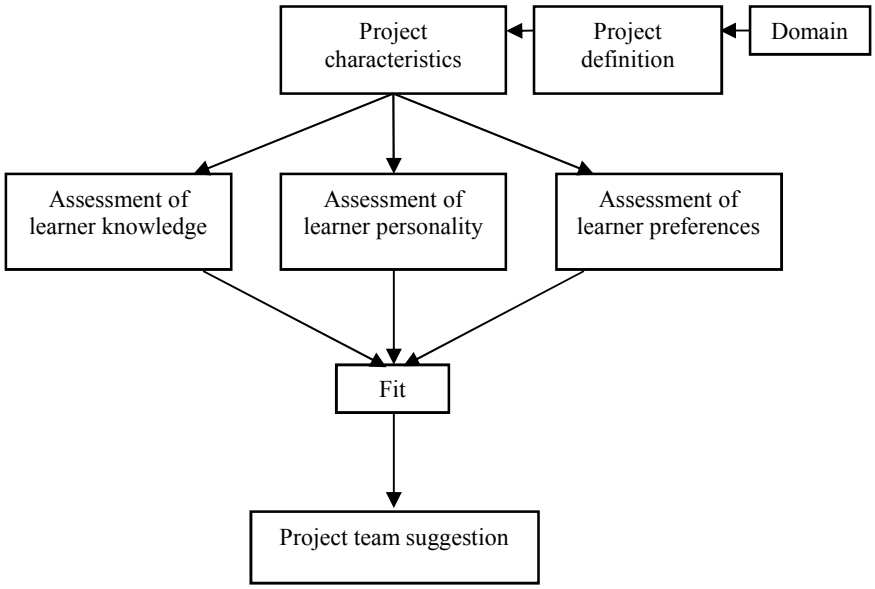

Figure 1: The project-based learning and team formation process model.

3.3 Qualifying fit

By allowing qualification of the fit between learners with respect to knowledge and personality, the process model opens up the opportunity to form teams aimed at different project work outcomes. These qualifications can be described in team formation rules. One such rule was already introduced above: Teams aimed at facilitating learning should be comprised of members with comparable personalities but with different knowledge backgrounds. Other rules might aim at forming teams that are targeted at other well-known project aims, such as creative problem solving, or expertly and productively solving a problem.

The principles outlined in the process model are based on the project-based learning and team formation theory introduced above, and are aimed at project definition and team formation in OLE settings. However, in order make sure we developed a process model which also receives support from project-based learning and team formation practitioners in the formal educational field, we conducted a field survey. The survey existed of interviews and a questionnaire. These had a two-fold aim: Firstly, ascertaining whether the team formation principles identified in section 2 and the process model presented in section 3 are aligned with PBL and team formation practice in formal learning settings, and secondly, to identify how the process model' affordance of differentiating team formations for different project work outcomes is valued. The method applied and the results obtained are presented in the section 4 and 5.

4 Method

In order to gain insight into team formation practise and feedback on the team formation process model, a field survey was conducted by means of an open access web-based questionnaire. Its initial setup was discussed in four semi-structured interviews with teachers and designers of project-based learning, who were also team formation practitioners. They worked at three different universities in the Netherlands. The interviews followed a predefined two-part schema. In the first part questions addressed team formation theory, practitioner experience, data used to form teams, team formation methods, and the recognition of team formation risks. The second part asked questions related to the proposed team formation process model with respect to the data categories we discerned, the desired teamwork outcomes, and whether it would be acceptable in practise to use outcomes of an automated team formation tool. In order to ensure a broad range in the experts' backgrounds in team formation, 2 interviewees were chosen from a distance teaching university and 2 interviewees were chosen from regular teaching universities (one technical university and one medical university, with an educational focus on problem-based learning). Of each type of institution, one interviewee primarily worked in supporting PBL on a daily basis and the other interviewee primarily worked in the development of PBL settings. The interviewees worked at three different universities. All had multiple years of experience in either supporting or designing PBL settings.

Following the feedback from the interviews, a web-based questionnaire was created with a list of 30 questions. The questions were split into four parts. The first part inquired into demographics, such as gender and current work place. The second part contained questions addressing team formation data and theory used in practice, the current team formation methods, how respondents dealt with strong and weak learners, differences in learner's background knowledge, learner personalities, minority aspects, and how learners were prepared for team-based activities. In the third part of the questionnaire the questions were related to the proposed team formation process. They addressed the principles of supplementary fit and complementary fit with respect to knowledge and personality, the categorisation of data suggested in section 3, the relative and absolute importance of the categories knowledge, personality and preferences in the team formation process. The relative and absolute importance could be indicated on a 5-point scale (1=not important, 5=very important). Respondents were also asked to indicate the importance of the proposed target outcomes of project-based learning on a 5-point scale (1=not important, 5=very important). The fourth part consisted of two open questions in which the respondents were asked whether and, if any, under which conditions they would accept a team formation suggestion from an automated tool, and whether respondents had general remarks on the suggested team formation approach. The questionnaire could be answered anonymously, and did not force respondents to answer all questions. Before respondents were invited to participate, 2 colleagues at the Open University in the Netherlands tested the questionnaire for intelligibility and logical correctness. Finally, the respondents were invited from international groups working and teaching in project-based learning settings, using an open invitation. The questionnaire was open for responses for 2 months.

5 Results

We present the results in accordance to the 4 parts the questionnaire was devided in.

5.1 Demographics and PBL settings

The in total 26 respondents stemmed from 8 different European countries. Of the respondents 29% were female, while 71% were male. 73% worked at a university, 15% worked at a university for professional education, while 4% worked in vocational training. No respondent reported to be working in the private sector. The respondents indicated that their students' team-based activities most often lasted between 3 and 6 months, while the extremes were 1 to 2 weeks and a whole year. The respondents indicated to be mainly active in project-based learning settings (40%) and problem-based learning settings (32%).

5.2 Project team formation practice

The respondents most often (41%) reported optimum team sizes to be between 3 and 6. When asked which team formation methods were in use, our respondents reported 12 unique team formation methods in total. Besides 9 teacher-driven team formation methods, they also reported 3 criteria for team formation based on learner self-selection. In order to compare these team formation methods with the data categories we identified above, in Table 1 we present the teacher driven team formation methods sorted into these categories. Please note that respondents could select more than one method (and even conflicting ones) since they would not necessarily use the same method in all team formation situations.

Category	Methods
Knowledge related	Group students with the same background knowledge (58%)
	Mix strong and weak students (27%)
	Heterogeneity in knowledge background (11%)
	Group strong students together (8%)
Personality related	Spread learners with similar personalities (21%)
	Group learners with similar personalities (8%)
	Group learners belonging to certain minorities (27%), such as form teams with only female members
Preferences related	Check for overlapping calendars (19%)

Table 1:Teacher driven team formation methods reported, related to the data categories knowledge, personality and preferences.

The respondents reported 3 methods, which were not categorisable: "Learner preferences for specific projects" (42%), "Allow students to self-select teams" (50%), and "Randomly select team members" (37%).

The respondents also reported on activities undertaken to prepare learners for successful teamwork. These were all aimed at preparing for self-selection: "Organizing joint meetings before team formation takes place" (33%), "Pointing to other students' prior track records" (28%), "Pointing to online profiles of other

students in social networks" (17%), and "Providing training in giving/receiving feedback and conducting negotiations" (67%).

5.3 The proposed team formation process model

The results presented in the tables 2 and 3 express the respondent' ratings on the (relative) values of the model' data categories when used in OLEs. Table 4 expresses the respondent' general opinions on desirability of the different project work outcomes we suggested.

Table 2 shows the results of our respondents' ratings of the overall importance of the individual data categories knowledge, personality and preferences for the team formation process. The combined scores of "rather important" and "very important" on knowledge are 64%, while the combined scores on preferences and personality are 60% and 12%, respectively. This score on personality is surprising, as it stands in contrast with the emphasis team formation theory puts on this category.

Importance	Knowledge	Personality	Preferences
Very important	28%	0%	16%
Rather important	36%	12%	44%
Important	28%	24%	28%
Somewhat important	8%	44%	12%
Not important	0%	20%	0%

Table 2: The importance of the categories knowledge, personality and preferences in the team formation process, on level of importance

The respondents also rated the importance of the categories knowledge, personality and preferences in relation to each other. These results are shown in Table 3.

Importance	Knowledge versus Personality	Knowledge versus Preferences	Personality versus Preferences
1st most important	8%	8%	4%
1st more important	50%	40%	20%
Equal importance	29%	28%	28%
2nd more important	13%	20%	44%
2nd most important	0%	4%	4%

Table 3: The importance of the categories knowledge, personality and preferences related to each other

The importance of the knowledge category was rated above the personality category. The importance of the knowledge category was also rated over the preferences category. The importance of the preferences category was rated over the personality category. This suggests a relative order of importance of the categories: (1) knowledge, (2) preferences and (3) personality in the team formation process. This outcome suggests that for future implementations of the team formation service, the

different data categories should be allowed to have different weights in the team formation process. None of the respondents indicated any other category of data to be relevant to the team formation process.

The respondents showed clear views on their preferred target outcomes of teamwork. The combined scores on "Very important" and "Rather important" for the outcome "Improved learning" scored highest with 76%, while the same combined scores for "Enhanced creativity" and "Improved productivity" scored 64% and 48% respectively (See Table 4),

Importance	Improved learning	Enhanced creativity	Improved productivity
Very important	48%	20%	8%
Rather important	28%	44%	40%
Important	24%	16%	36%
Somewhat important	0%	20%	12%
Not important	0%	0%	4%

Table 4: Preferred target outcomes of project-based activities, on level of importance.

5.4 Accepting team formation suggestion from a team formation service

In the fourth part of the questionnaire the respondents were asked whether and under which conditions they would accept a team formation suggestion from an automated tool, and whether respondents had general remarks on the suggested team formation approach. Of the 11 responses to the first question, 5 express acceptance of automated team suggestions. Another 5 responses express acceptance with some reservations, while 1 response expresses declination of automated team suggestions. (Some text has been translated from Dutch to English, or edited for reasons of readability.)

Responses expressing acceptance
"It would solve for us a problem with the formation of complete teams."
"My students sometimes already use a program (written by some of our students as a design exercise) "find study buddy" in which they can vary criteria like location distance or number of same courses taken to find a buddy."
"Following a suggestion is always better than entering a team completely blank."
"I would. You don't have to spend time to be on a team. Everybody is in a team. A disadvantage is that a student with negative experience with another student will not accept the result of a computer when this particular student is selected in his team."
" Yes, it will provide me the possibility to discuss with new people and I'm expecting that it will be a good collaboration."

Responses expressing conditional acceptance
"I would accept, simply because it takes time to take into account multiple criteria to form teams, and also because it will only be a suggestion."
"I would accept such a suggestion and also the students would as a basis for further investigation in forming an optimal team."

"Maybe ... if students already know each other, they might know better with whom they might work better than an automated system. Otherwise, one such system would manage to group them better then they or the teacher can."
"Suggestions are always helpful by providing a deeper insight into the team selection process. The final decision should be taken by the tutor, but an automatic system could present valuable facts and recommendations (mostly about prior knowledge, previous teams, and other member's preferences)."
"Yes, if I agree with the selection".

Response expressing declination
"No, I would like to experience different teams myself, to learn more about different competences. An automatic system leaves no space for experiments in your own personal competence growth."

General remarks
The respondents gave the following general remarks on the research presented (responses not directly related to the current research have been omitted):
"The suggested approach to team formation seems much more thoughtful when compared to my current practice".

6 Discussion

The primary research question we addressed in this paper was: "*Which principles and processes underlie the introduction of project-based learning and team formation in open learning environments, given the specific characteristics of open learning environments and their users?"* Before we present our conclusions we first discuss the results from the interviews and questionnaire:

When we compare the team formation methods reported to be in use in practice with the categories knowledge, personality and preferences, we find that some methods (learner preferences for specific projects, allow students to self-select teams, randomly select team members) cannot be related to the categories suggested, as they relate to learner-self-selection-based team formation. The team formation theory we examined considers the use of such criteria to be detrimental to the quality of the outcomes of teamwork. They are therefore discarded from our design.

Some criteria seem to be in contradiction to each other. In the knowledge category, the criteria "group students with the same background knowledge" and "heterogeneity in knowledge background" and the criteria "mix strong and weak students" and "group strong students together" look contradictory. However, this may well be explained by the respondent's focus on facilitating learning or enhancing creativity. Contradictions in the personality category can be explained in a similar way.

There is only one mention of a preferences-related criterion ("let students themselves check for overlapping student calendars"), which can be explained by the fact that our respondents work with cohorts of learners in traditional educational settings that show homogeneity in, for example, the preferred language or available time slots for project-based collaborations.

The overall relevance of the categories knowledge, personality and preferences for the team formation process show a low value for personality. Where "knowledge' receives a joint score of 64% on "important to very important" and "preferences" receives a joint score of 60%, "personality" only scores 12%. This outcome is somewhat surprising given the emphasis team formation theory puts on personality as an import factor in a team formation process. This might be explained from the fact that practitioners in team formation from the educational field might not be able, or do not have the instruments to assess personality easily. This score can also reflect the lack of respondents from the private sector, where tests related to personality aspects are a more mainstream part of e.g., job application procedures.

We found the relative order of importance of categories of data in the team formation process to be: (1) knowledge, (2) preferences and (3) personality. However, fit in preferences indicate "condiciones sine qua non", as without overlapping preferences collaboration cannot take place. The fit in preferences therefore precedes the fit in knowledge and personality, which are the important factors when forming teams targeted at specific outcomes.

The practitioners put an emphasis on "improving learning" as a desirable project aim. Given that the respondents all stem from a background in education, this can hardly come as a surprise. However, the almost equally strong emphasis on "enhance creativity" suggests that "improve learning" and "enhance creativity" should both be supported target outcomes in a team formation process for educational purposes. The private sector might put more emphasis on "improving productivity" as a desirable outcome. To allow the team formation tool to be used in a wide range of settings, we aim to support all three of the suggested target outcomes.

From the remarks we received about the acceptance of team formation suggestions from an automated tool, we get the distinct impression that such a tool would be welcomed. This welcome is in some respects conditional. Some teachers would like to be able to use the tool for input into a team formation process they can oversee themselves. The reservations mostly apply to traditional educational settings and have less bearing on the possible benefits a tool can have for setting up project-based learning and team formation services in OLEs, where no other support is available. A reservation about the possibility to create a meaningful personality profile is duly noted. However, from the team formation theory we conclude that inclusion of a personality profile improves the team formation process beyond the current practice, also in traditional settings.

7 Conclusions

Learners in OLEs have to show continuous self-motivation to learn in relatively anonymity. As this is inherently difficult, the practice-oriented, motivational, and coherence-creating affordances of project-based learning can support these learners. There are, however, significant differences between setting up PBL in formal, teacher-led learning settings and OLE settings, in which teachers play only a small part. In traditional settings practitioners (e.g., teachers) would normally initiate PBL, using their expertise related to learner knowledge and personality, the curriculum and the task to be designed. Due to the number of learners in OLEs, we assume no support will be available to start the PBL and team formation process. Because of the

learners' different backgrounds we also assume that not all data will be available that would otherwise be available in formal learning settings. We suggested a solution to these problems by allowing the process of starting PBL and team formation to be carried out by learners themselves. But these learners probably lack the knowledge to perform the team formation process. We therefore need to design support, with learner self-direction and self-organisation in mind.

The PBL and team formation theory introduced suggested that data is required on the project and on the learner' knowledge and personality. The OLE context required the inclusion of a third category of data: Preferences. From these categories we constructed a process model, aimed at the introduction of PBL and team formation support for OLE learners. The model describes "fit" as the result of an optimisation process, which matches prospective team members into a team for a specific project. We further introduced team formation rules that can influence the team formation process toward setting the stage for mutual learning and teaching, enhancing the possibility of a creative project outcome or to improve productivity. We expect that the different team formation methods mentioned in the survey results in section 5.2 can be translated into these team formation rules.

The data we identified from theory as playing a role in team formation process largely overlap with the data used by team formation practitioners; therefore we conclude that theory and practise at large are aligned. The exception is the data on personality, which receives more emphasis in theory then in practise. We assume this is due to the inherent difficulty in measuring and taking into account this data in the team formation process. There is a strong tendency to focus merely on knowledge as a general indicator for success, despite studies that indicate that other factors are more predicative of success [Roberts, Kuncel, Shiner, Caspi and Goldberg 2007]. As the inclusion of the category personality gets support from team formation theory, we consider it to be an important factor in team formation.

Our respondents find knowledge to be the most important category of data to be used in the team formation process, over preferences and finally personality. This result indicates that being able to give these categories different weights in the team formation process would be an important asset for a team formation service. The respondents express strong support for the possibility to direct team formations toward the outcomes we suggested. They indicated a clear order in which they prefer the different targets; from the most preferred "Improve learning", to "Enhance creativity" to the least preferred "Improve productivity". Nevertheless, all possible outcomes suggested receive high importance rates. From this we conclude that it will be important to also provide OLE learners or teachers with the opportunity to indicate the preferred project aim when they use the envisaged PBL and team formation service.

Our final conclusion is that the question "*Which principles and processes underlie the introduction of project-based learning and team formation in open learning environments, given the specific characteristics of open learning environments and their users?"* can, in principle, be answered by our process model. The model receives support from the educational field, although support for the use of the category personality is limited. However, as team formation theory values this category highly, we think we should design a PBL and team formation service taking personality into account. This would also provide the opportunity to implement the

team formation rules, which depend on variations in both knowledge and personality fit. An implementation of the service including this category can also improve the team formation practice in traditional learning settings, even when it is only used to provide team formation suggestions and leaves the final team formation decision to the expert.

8 Future work

In the next step of our research, we will focus on the technical aspects of transforming teacher-based PBL and team formation into an implementation of service-based PBL and team formation. It will take into account the data to be gathered upon which to base a PBL and team formation service, and how these data can be gathered and analysed so they can be mapped to knowledge, personality and preferences. When the learners are students enlisted at an educational institution and follow an official curriculum, some of the data needed could be mined from the educational administrative systems. However, when an OLE primarily attracts self-directing lifelong learners (links to) these data will have to be provided by the learners themselves. Our future work will also address the definitions of fit (expressed in team formation rules) with respect to the different project work outcomes. For the knowledge category we firstly plan to use learner self-reported levels of knowledge on the project task. Later on we envision this method of knowledge assessment will be replaced by a means to relate both project descriptions and learners' project applications (or CV's, e-porfolio's or materials studied earlier) to materials available in the domain (cf. [Laham, Bennett and Landauer 2000]). The learner personality will be assessed with the help of available tests, such as the Big Five test [Barrick and Mount 1991]. The preferences will be based on a learner profile. Each step of the development of the service will be evaluated with students and teachers, taking into account both the ease of use and the quality of team formation advice generated.

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