VALUE-DRIVEN FACILITATION OF PROJECT-BASED LEARNING: DOMAIN KNOWLEDGE, DIDACTIC GUIDANCE, AND METHOD SUPPORT

Iniga Antonia Baum[1]
Christian Stary[2]

Abstract: In this study we consider Project-based Learning (PjBL) processes from an Organization Learning perspective. We investigate how facilitators can become triggers and drivers of developing PjBL in a knowledge-based and participatory way for all involved stakeholders in an institutional (learning) setting. The developed and presented instrument which contextualizes value transactions among the networked PjBL stakeholders through empirical PjBL evidence. PjBL success factors and guidelines for effective PjBL frame Value Network Analyses. The demonstrator has been tested in a master course in Business Informatics on Digital Twin generation. Besides the proof of concept, the feasibility of continuous advancements through facilitator participation along individually organized development steps could be demonstrated.

Keywords: Project-Based Learning (PjBL); learning support; Value Network Analysis (VNA); Complex Adaptive Systems

Resumo: Neste estudo, consideramos os processos de Aprendizagem Baseada em Projetos (PjBL) a partir de uma perspectiva de Aprendizagem Organizacional. Investigamos como os facilitadores podem se tornar gatilhos e impulsionadores do desenvolvimento de PjBL de forma participativa e guiada pelo conhecimento para todas as partes interessadas envolvidas em um ambiente institucional (de aprendizagem). O instrumento desenvolvido e apresentado contextualiza as transações de valor entre as partes interessadas PjBL em rede por meio de evidências empíricas de PjBL. Fatores de sucesso PjBL e diretrizes para análises de rede de valor de quadro PjBL eficazes. Além da prova de conceito, a viabilidade de avanços contínuos por meio da participação do facilitador em etapas de desenvolvimento organizadas individualmente pode ser demonstrada.

Palavras-chave: *Aprendizagem Baseada em Projetos (PjBL); suporte à aprendizagem; Value Network Analysis (VNA); Complex Adaptive Systems*

Resumen: En este estudio consideramos los procesos de Aprendizaje Basado en Proyectos (PjBL) desde una perspectiva de Aprendizaje Organizacional. Investigamos cómo los facilitadores pueden convertirse en desencadenantes e impulsores del desarrollo de PjBL de una manera participativa y basada en el conocimiento para todas las partes interesadas involucradas en un entorno institucional (de aprendizaje). El instrumento desarrollado y presentado contextualiza las transacciones de valor entre las partes interesadas de PjBL en red a través de la evidencia empírica de PjBL. Factores de éxito de PjBL y pautas para análisis efectivos de red de valor de marco de PjBL Además de la prueba de concepto, se pudo demostrar la

1 Business Informatics-Communications Engineering - Johannes Kepler University Linz – Austria. ORCID: https://orcid.org/0000-0001-9764-5021. e-mail: christian.stary@jku.at

2 Business Informatics-Communications Engineering - Johannes Kepler University Linz – Austria. ORCID: https://orcid.org/0009-0009-2792-0409. e-mail: i.antonia.baum@gmail.com

viabilidad de avances continuos a través de la participación del facilitador a lo largo de pasos de desarrollo organizados individualmente.

Palabras clave: Aprendizaje Basado en Proyectos (PjBL); apoyo al aprendizaj; Análisis de Redes de Valor (VNA); Sistemas Adaptativos Complejos

1. INTRODUCTION

The Project-based learning (PjBL) approaches learning processes in a highly contextualized and focused form. With goal-setting that concerns challenges and problems students may face in real settings, learners are encouraged to self-organize problem solving processes and collaboration while developing knowledge and skills through project practice (cf. Krajcik *et al.*, 2006; Kokotsaki *et al.*, 2016; Suastra *et al.*, 2019). Studies including Jonassen *et al.* (1993) and Surmani (2013) investigated student behavior in various learning environments, while isolated research can be found on the perceived role understanding of facilitators when teaching in those settings. Since PjBL has been recognized as a student-driven, but teacher-facilitated approach to learning (Saad *et al.*, 2022), we need to understand why facilitators respond differently to the same challenges, and what can be done to better support and sustain this type of constructivist learning processes (cf. Rosenfeld *et al.*, 2006).

What has become evident from various PjBL implementations, e.g., in engineering education (Guerra *et al.*, 2017), is that facilitators experience several challenges (Rosenfeld *et al.*, 2000; Scarbrough, 2004). They have been reported on the individual level for teachers and students, as well as on the institutional level and the culture level, calling for optimization of curricula design and informed preparation to implement PjBL successfully (Chen *et al.*, 2021). Consequently, facilitators need to develop a thorough understanding of their role in PjBL processes. One way of support is to handle facilitators' agency in terms of beliefs. It helps to reveal 'the individual and collective discourses that inform teachers' perceptions, judgements and decision-making and that motivate and drive teachers' action' (Biesta *et al.*, 2015, p. 624). Facilitators hold many different kinds of beliefs, not only concerning their sense of agency (how they teach) and individual knowledge, but also about the drivers and motivation of their students (Levin, 2014). However, these beliefs might not be present in the enacted practices (Bühl *et al.*, 2015), possibly due to 'an apparent mismatch between teachers' individual beliefs and values and wider institutional discourses and cultures, and a relative lack of a clear and robust professional vision of the purposes of education' (Biesta *et al.*, 2015, p. 624). These findings 'indicate that the promotion of teacher agency does not just rely on the beliefs that individual

teachers bring to their practice, but also requires collective development and consideration' (ibid.).

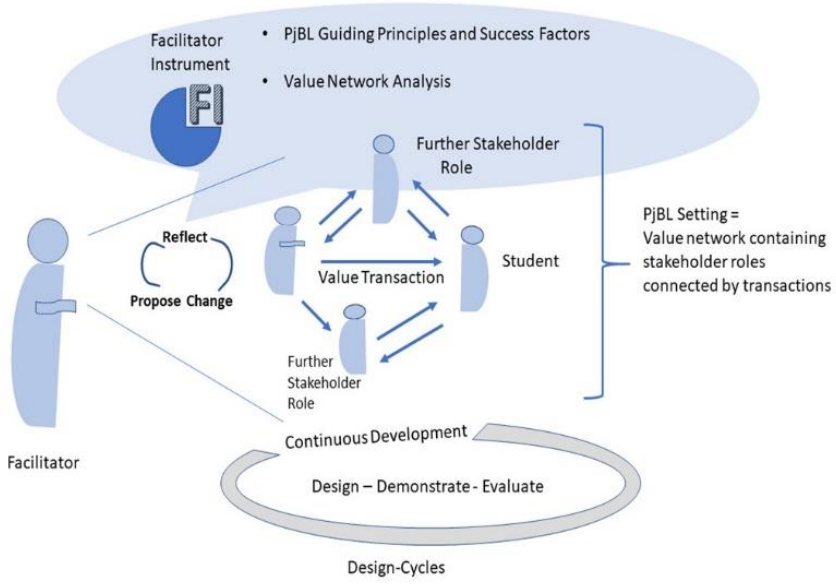
In this paper we make a step to overcome this lack of congruence and to enable collective development, as we want to uncover the facilitators individual perception of practice as part of their interaction with students and other stakeholders considered relevant or valuable in their educational context. Therefore, we tackle the following research questions:

(i) Which value exchanges do facilitators perceive when performing PjBL activities?

(ii) How can they be supported to implement PjBL according to the state of art and envisioned value transaction[3]*s?*

In order to understand the value transactions that may support or hinder the connection with students and institutional actors, we enable PjBL facilitators to explore their perception of valuable interactions along learning processes, in particular when performing PjBL activities in a higher educational setting. For eliciting, representing, and sharing of value transactions the Value Network Analysis (VNA) (Allee, 2009) is deployed, and framed by experiential PjBL knowledge when implemented as part of the "Facilitator's instrument (FI)"– see to figure 1.

Figure 1 – The Facilitator's Instrument (FI): Evidence-based framing the exploration of value exchanges



PjBL activities are organized as a network of value transactions between involved stakeholders while addressing their functional role. Each functional role denotes didactically

[3] A value transaction is the exchange of information, material, or services between stakeholders in a specific network and between specific roles (e.g., student, facilitator, coach, expert, educators, and the like) considered to be relevant for PjBL or contributing to successful PjBL.

grounded interventions or organizational responsibilities (cf. Weichhart *et al.*, 2018). Reflection and informed proposal for change are part of continuously evolving development cycles, involving further stakeholders PjBL and sharing value exchanges.

The paper starts with reviewing related work on value exchange exploration in PjBL. Subsequently, we detail the instrument and exemplify its use, before we discuss the results of our first design including the performed field study, answering the addressed research questions. In the conclusion we wrap up the findings for practical use and future research.

2. LITERATURE REVIEW

We structure the related work according to existing approaches capturing the role understanding of facilitators and operational support, i.e. methods and tools to implement PjBL.

Facilitators as partners in PjBL transactions. Collaboration is considered one of the main drivers of learning processes in PjBL, in particular among students, with teachers, and further communities or societal groups, affecting planning activities and solving problems in terms of self-organizing answers to questions and using technology tools (Kokotsaki *et.al.*, 2016; Finzer *et al.*, 2018; Hussein, 2021). The study of Guo *et al.* (2012) concerned a tele-collaborative PjBL project with institutional stakeholders (partner schools), teachers, and students - see Figure 2. When carrying out projects, teachers were receiving training from subject experts and researchers, and got involved in project planning and managing the collaboration with students. Project-related collaborative inquiry and the focused interaction with students triggered major changes of behavior and supported facilitation, including the organization of leaning processes and collaboration capabilities. Habók *et al.* (2016) could identify the transmission of values key to PjBL in teaching situations. The latter might conflict to teacher-led approaches when introducing PjBL (Sherwood *et al.*, 2020), and influence the shift from lecture to coaching-driven facilitation (Chiu, 2020).

Figure 2 – Sequence of steps for professional development of facilitators improving learner performance (according to the study by Guo *et al.*, 2012)

Instruments for Facilitator Development. Teachers might not find it easy to adopt PjBL support activities, albeit appreciating the constructivist approach to learning (Tamim *et al.*, 2013; Rosenfeld and Rosenfeld, 2006). Guo *et al.* (2012) have studied a collaborative effort to PjBL, with the aim to foster stakeholder engagement that leads to professional development of teachers. The methodological approach to this increase of effective facilitation and learning processes has been depicted like shown in Figure 2. Collaborative inquiry activities seem to be key for development support, as also shown by the study of Habók *et al.* (2016): Group-based methods and the cooperative method have been considered one of the mainly applied designs. However, these methodological findings have not been put into context of transformation models addressing facilitator involvement. According to Sherwood *et al.* (2021) various approaches to introduce PjBL (in this case computational thinking) could be identified: (i) a single teacher leader-driven model, (ii) a scaffolded professional development model, and (iii) an intense coaching model. In case digital technologies are part of PjBL initiatives or facilitation, implementation difficulties arise due to the lack of support from school management teams and the inadequate provision of technological tools. The latter hinders the required contextualization and the development of facilitator role understanding, and finally collaborative PjBL (Gómez-Pablos *et al.*, 2017).

Putting the findings from related work into the context of the research question on developing a PjBL role understanding of facilitators, the research reveals (i) that facilitators continuously collaborate in PjBL with learners, and (ii) the development of role understanding requires domain knowledge that needs to be accessible in the course of adopting PjBL in course or classroom settings. Hence, a support instrument should contextualize and guide the design and implementation of PjBL activities for a specific course or classroom setting.

3. THE FACILITATOR'S INSTRUMENT – CONCEPT AND LOOK & FEEL

We introduce the Facilitator's Instrument (FI) in the context of a Business Informatics course, the Summer School on Digital Twin generation. We start with fundamental design considerations and the general structure before exemplifying its use.

The development instrument has been designed (i) to frame the Value Network Analysis by PjBL evidence, and (ii) to be self-contained in the sense to capture the background of the FI development, its use, and practical application. This objective has led to design the entry page as shown in Figure 3, revealing the entry points What it is About, How to Use it, Use It!, Feedback for Developers, Feedback for (Teacher) Community.

Once the UseIt! option is selected, the context items as list of guiding principles and success factors is displayed on top of the screen. These factors are meant to focus on requirements that should be met when putting PjBL to educational practice. As such, they should become instantiated as value transactions at some point between PjBL stakeholders. For instance, Collaborative Learning as requirement could be instantiated as Q&A sequences between learners and facilitators or peers, however, triggered by learners.

Figure 3 – The Facilitator's Instrument implemented in Prezi (www.prezi.com) - Opening screen providing the rationale, guidance for use, and feedback option

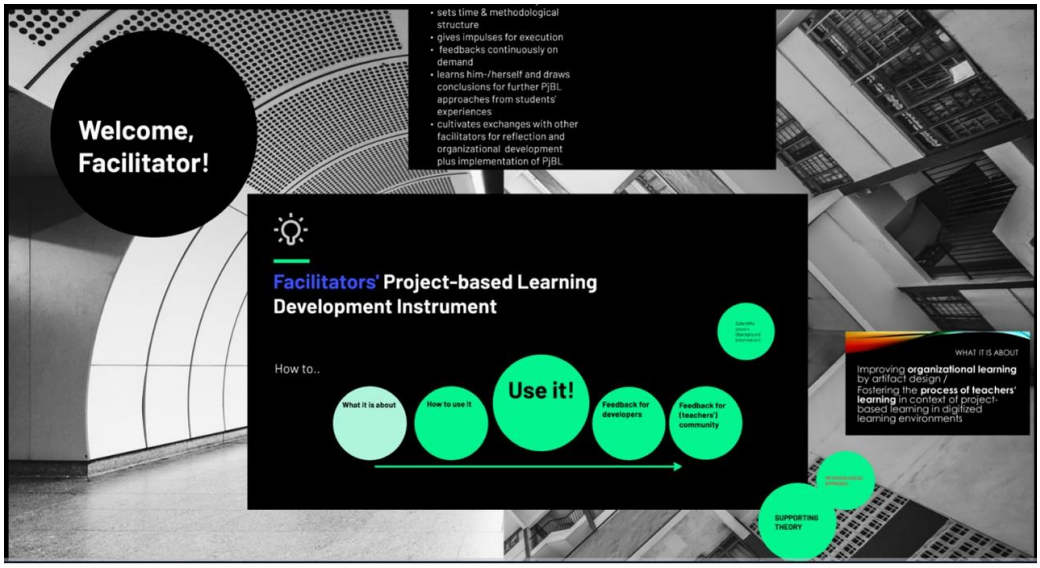
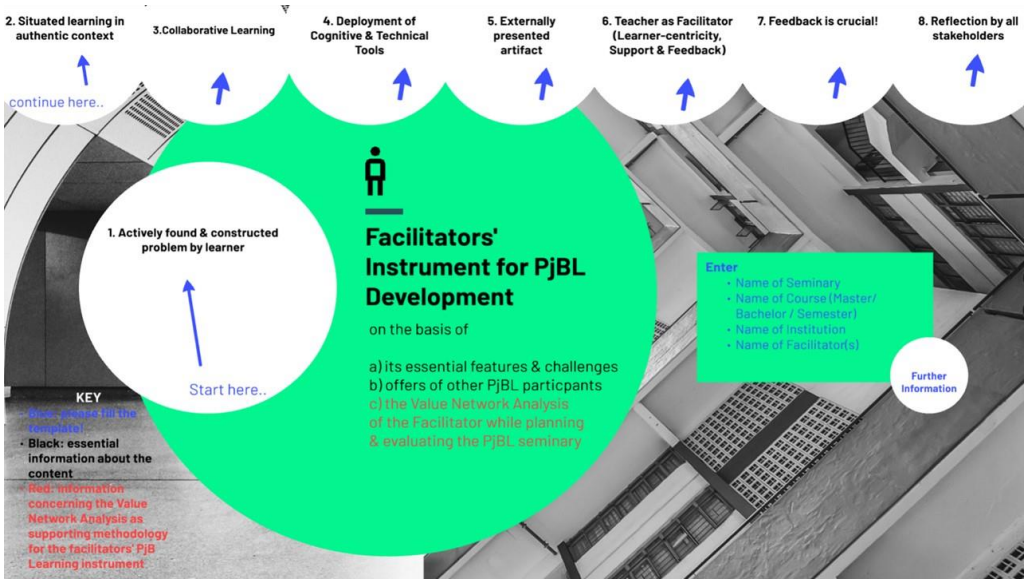


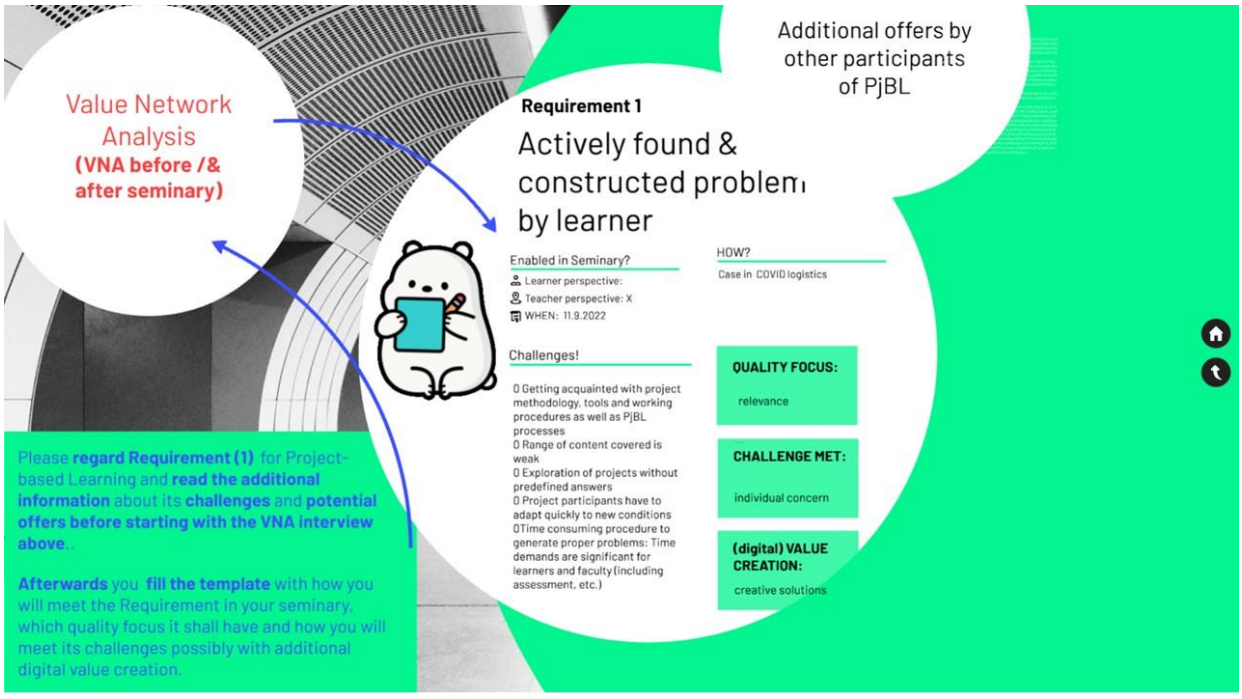
Figure 4 – FI - Framing the VNA by evidence represented as requirements to be met in PjBL practice – these requirements are intended to guide the design of the PjBL-based learning setting later refined by the VNA



When activating the Value Network Analysis in FI, each of the listed guiding principles and success factors (represented as PjBL requirements) can be used to look from a certain perspective on the PjBL network of stakeholders. As indicated in Figure 4, the selected perspective is: *1. Actively found & constructed problem by learner*, which frames the specification of value transactions. It is explained a dedicated step and part of the FI, as shown in Figure 6. Next the requirements can be worked through in the predefined sequence: *2. Situated learning in authentic context; 3. Collaborative learning; 4. Deployment of cognitive & technical tools; 5. Externally presented artifact; 6. Teacher as Facilitator (Learner-centricity, Support & Feedback); 7. Feedback is crucial; 8. Reflection by all stakeholders.*

Within the specific subpage for each guiding principle of PjBL facilitators will find a set of information for their individual preparation of the course: *Challenges!* will show them some typical challenges which may occur while aspiring to implement this component of PjBL (as found in PjBL literature) so they are prepared to be confronted with these in advance. Further, the bubble *Additional offers of other participants of PjBL* leads to ideas and proposals which were gathered by VNA method with PjBL stakeholders in their specific PjBL contexts. Facilitators are asked to decide for their own quality focus, the way they propose to meet the challenges within this requirement and their assumption about a possible, potentially digital value creation with this suggestion made, after having themselves preoccupied with the information given in this section.

Figure 5 – FI - Guiding principles & success factors detailed for successful PjBL practice –ex. Requirement 1



After having selected a PjBL requirement the facilitator is introduced to the basic steps of the Value Network Analysis (VNA) – see Figure 6. The initial step is to create a diagrammatic representation of a holomap, i.e. the network of PjBL actors, and their relations (see Figure 7). These relations can either be tangible (i.e. from the stakeholder role required), or intangible (i.e. not formally required but informally provided for the sake of successful PjBL processes).

Figure 6 – FI - Entering the VNA after selecting a PjBL requirement

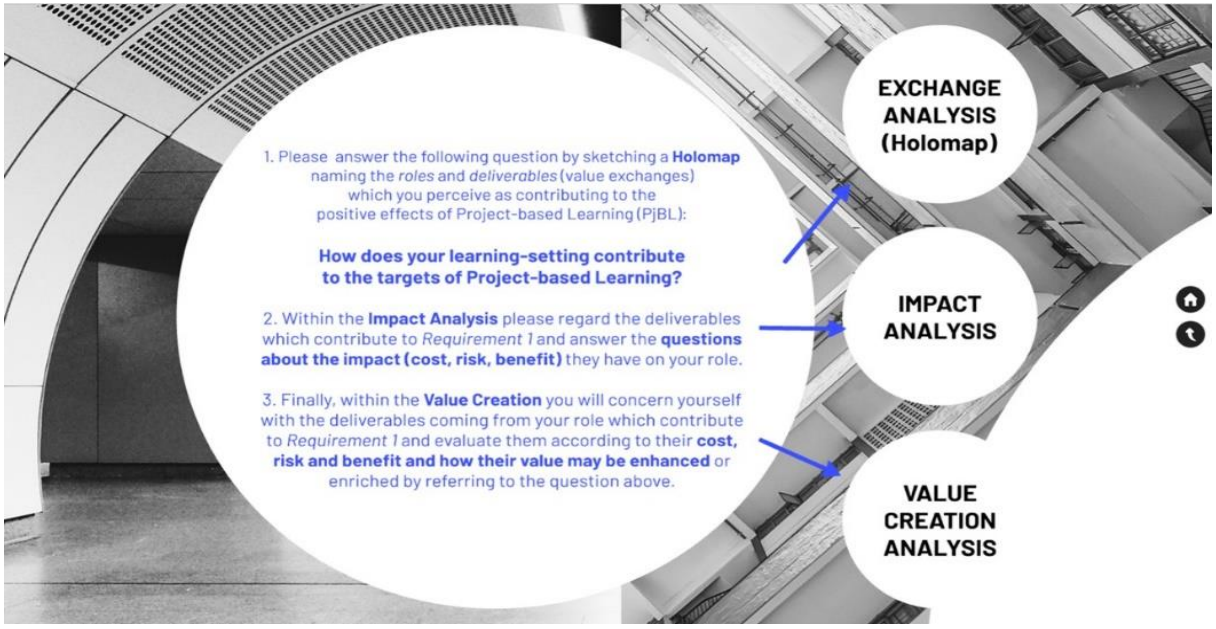
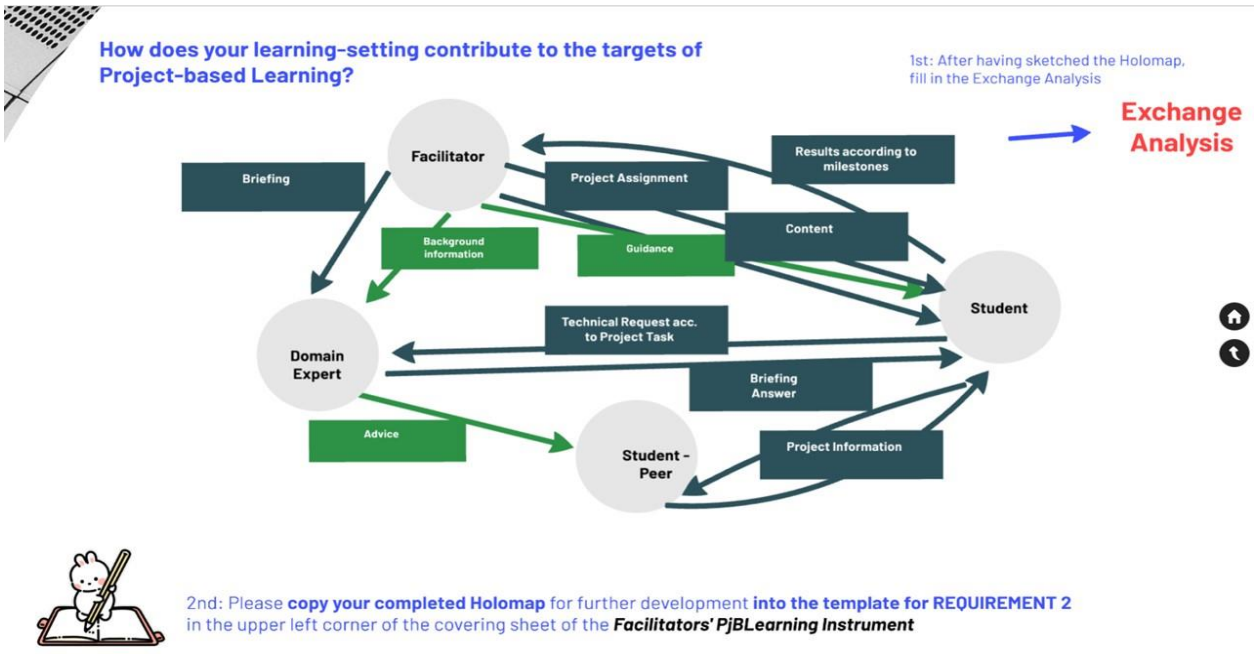


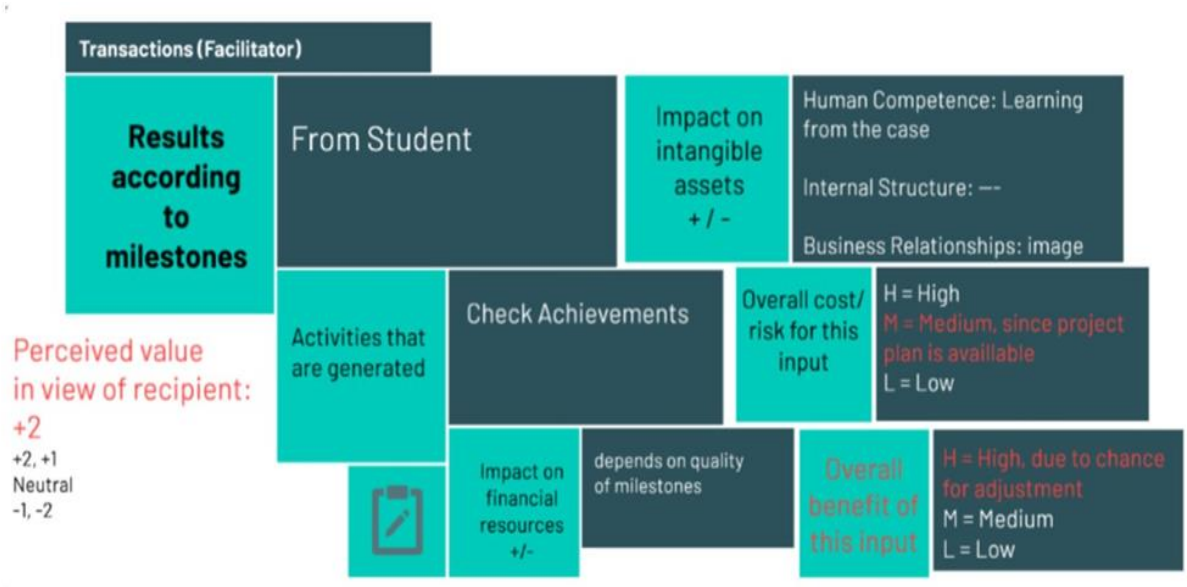
Figure 7 – FI - Initial VNA step: Creating a network of PjBL stakeholders and their formal tangible (black) and additional intangible (green) value transactions – the facilitator is asked to identify relevant roles (circles) initially



The shown holomap and the VNA tables have been created as a demonstrator for the Summer School for Digital Twin Generation by its facilitator. In the Summer School 35 students in the Master program on Business Informatics are invited to create a digital process twin in a PjBL setting. Within 4 days in groups of 4-5 learners they define a cyber-physical system, such as a warehouse system with a robot-supported packaging process (Stary et al., 2022. In addition to the digital process twin the physical sensor sub system need to be implemented.

The holomap shows regular patterns that are of interest when looking for outgoing deliverables that have impact on the behavior of other network actors. The interaction patterns of the holomap should reveal cyclic interactions denoting value exchanges. This means, each delivered output should either lead to a direct or indirect input for each of the stakeholder – in the use case (Figure 8) a regular patterns of value transactions.

Figure 8 – VNA's impact analysis exemplified for the value transaction 'Results according to milestones of a project, delivered by the student – the dark cells are inputs from the VNA user and contain triggered activities like 'Check Achievements' and estimates on the input's impact when performing the activity



The second analysis of the VNA has its focus on transactions from each stakeholder pointing to the facilitator. Its visual appearance in FI is given in Figure 9, detailing for the facilitator the impact of received transactions the way provided by Allee (2003). The third analysis of the VNA has its initial focus on outgoing deliverables from the facilitator to different stakeholders of the value network and its second focus on additional value transactions to improve the collective performance of the network, even by complementing additional stakeholders (see Figure 9 and 10).

Figure 9 – VNA's value creation analysis (part 1) - the dark cells are inputs from the VNA user and contain created outputs like 'Guidance' and estimates on their perceived value and impact on the receiver(s)

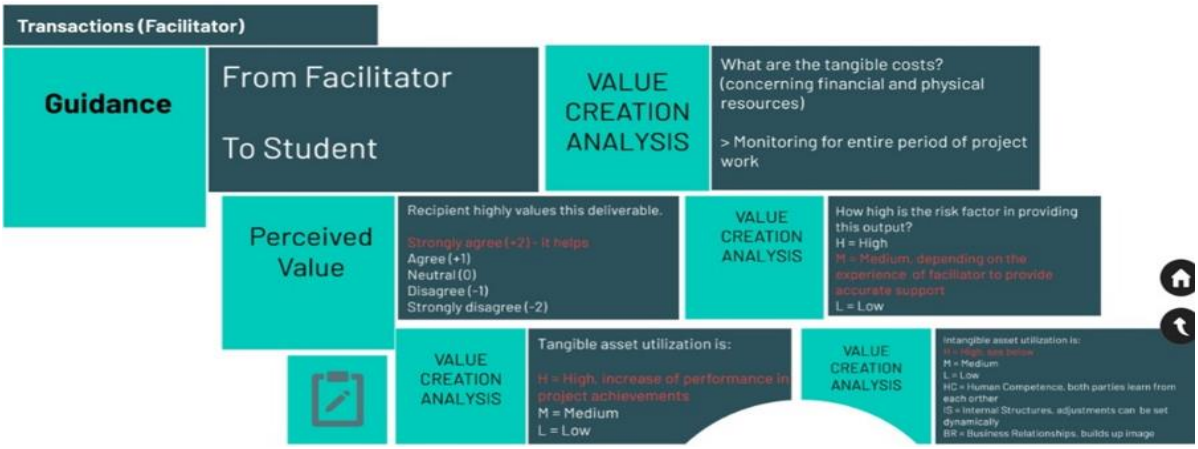


Figure 10 – VNA's value creation analysis (Part 2) - the dark cells are inputs from the VNA user and contain for created outputs like 'Guidance' estimates on their costs/risks and overall benefit

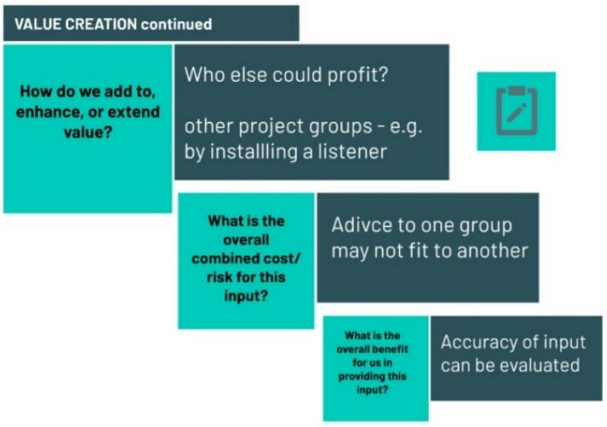
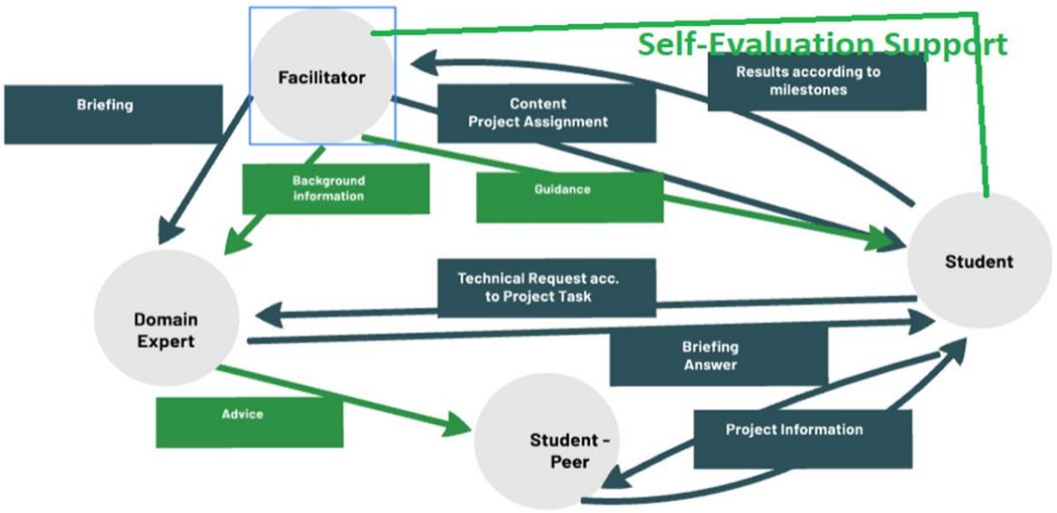


Figure 11 – Improved value transaction – Self-Evaluation Support has been added



The final step reconsiders the initial holomap adapting it to the envisioned changes – in Figure 11 a self-evaluation report is added as intangible transaction for meeting PjBL requirement 1, as it seemed to be of value for the facilitator that students are graded in the basis of self-evaluation in addition to the way currently handled.

4. EVALUATION

In this section we summarize our findings from the case addressed above, and then report on additional experiences when presenting the FI to facilitators.

Several difficulties in the practical use of the FI were detected and mirrored by the facilitator, showing that the FI needs further improvement and adaption: First of all, the editing format in PREZI (www.prezi.com), which was deployed as cause of its contingency to show and redact different and complex issues in an overview as well as a zoom-in-zoom-out perspective, produced challenges for the designers as well as testing facilitators. The possibility to zoom into a variety of contexts by choice was not intuitive for all users and led to confusion as where and with which action to start in the FI. Also, the desired point in time, the demanded content to fill into certain boxes (for example about the intended quality of a specific PjBL requirement, see to Figure 5) and the reason why to do this, was not fully clear to the facilitator testing the FI at first.

The next feedback after testing was that the drawing of the holomap requires some sensitivity and acquaintance with the tool as well as with the idea of the value map of a network itself. Further, filling in the graphically adapted tables *(Impact Analysis, Value Creation Analysis)* in the FI was noticed as hazardous because of constantly changing font sizes at different question boxes (Feedback by the facilitator of the Summer School when initially testing the instrument: “Readability of text strongly depends on screen size when editing.”). In addition, copy and paste of the holomap for treating it within the context of another requirement or for duplicating the same questions for working at new deliverables was basically not feasible.

Besides those technical constraints, tests with the instrument and further facilitators showed, that the readiness for reflecting and possibly improving one’s individual PjBL lecture depends strongly on the disposition and pre-experience of each facilitator. For example, the described case was demonstrated with a lecturer with high knowledge about PjBL processes and similarly high familiarity with the VNA method itself. Therefore, he had less difficulties working with it, even though some technical defaults came up while he was analyzing his planned PjBL setting according to possible effects and value transactions by deployment of the given VNA tool. Another presentation of the FI resulted yet in a very different dealing: the

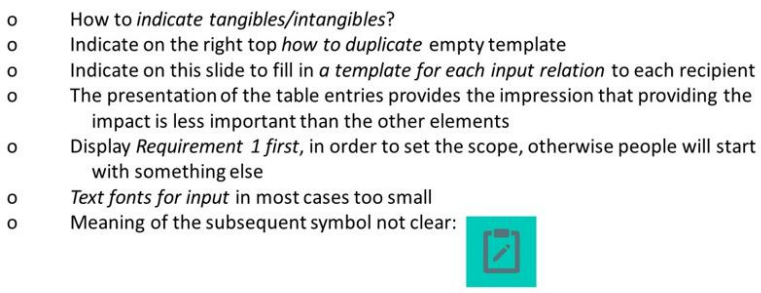
respective facilitator of a Project Management seminary did not fill in any VNA holomap or table by himself, presumably as he had not been acquainted with the method before taking part at the demonstration. He claimed being too occupied for it on the one hand, but was on the other hand very interested in the eight guiding principles for PjBL depicted in the FI and how he could implement some of them in his courses for improvement. The preparation and the evaluation test session therefore focused mainly on the guiding principles as cause of his concern, while the VNA was merely conducted as an irksome duty by him with little expected effect for his further PjBL development (out of his view).

5. SUGGESTIONS FOR IMPROVEMENT

Relating to the first feedbacks it is to ascertain whether solely format changes within in the FI (e.g. simplifying, speeding up mechanisms, visual appearance) might support its objectives, or whether the design of the FI rather needs to discern itself with differing conceptual approaches according to facilitators' backgrounds and motivations in order to set adequate entry points.

For the first assumption, the facilitator of the Summer School had some content-related improvement recommendations, as for example more exact definitions (of intangible deliverables) in order to meet better the intention of the VNA about the desired category. Besides, he suggested to provide more information to a processing facilitator about how to exactly compose the holomap. Further improvement suggestions for the Impact Analysis and the Value Creation Analysis were proposed by the facilitator in detail about the filling in the respective information:

Figure 12 – Questions/Remarks for improvement when using the FI



Referring to the possibility to change the conceptual approach of the FI a recommendation by the facilitators was to make very clear at the beginning within the FI, the answers to the following questions: *Why is this interesting for me? (What is the immediate value of the VNA in this context?) Where am I? (in the sense of sorting one's own actual*

understanding of PjBL) What is my invest? Where can I start? Another strong request, was about taking out complexity in order to motivate using the tool to "simplify teacher's life." Further hints for refinement of the entry point could be leveraged in the testing facilitators' quest for explanation whether the FI could enhance student engagement, whether there were practical tips to enhance PjBL seminaries and whether the instrument could demonstrably contribute to competence development of students.

6. DISCUSSION

When making a step to develop facilitator capabilities as collaborative endeavor to successfully establish PjBL in their specific educational setting, we intended to uncover the facilitators' individual perception of practice as part of their interaction with students and other stakeholders. Hence, we asked for those value transactions and exchanges they individually perceive when performing PjBL activities, and designed methodological and tool support to implement PjBL on the basis of the respective current cognition of each facilitator.

The exemplary use case enabled the collection of conceptual and empirical knowledge on PjBL. It served as context to reflect on value transactions and suggest changes in interaction. Both were integrated into the Facilitator's Instrument and turned out to work in a demonstrator prototype as intended.

One effect which was found with two facilitators testing the instrument was their direct implementation of *Requirement 1: Actively found and constructed Problem by learner* into the next planned PjBL seminary. The resulting changes and possible enhancements in their PjBL setting will be evaluated in the next development cycle. It seems the arrangement of guiding principles plays a role, in terms of placing the most important one on the left, when facilitators apply the 'left-to-right' sequence in the course of holomapping and the subsequent network analyses.

7. CONCLUSION

With Project-based Learning (PjBL) allowing learners to organize learning processes on a topic of their interest, the role of facilitators requires (continuous) transformation support. In particular, when PjBL is established in institutional settings, traditional role models of teachers have to undergo significant transformation. Although various approaches turned out to be part of practice, structured and transparent support for the different stakeholder groups (learners, educators, authorities, consulting experts etc.) has not been considered from an organizational development perspective so far. In this paper we have reported on applying a well-estab-

lished organizational development method in the education domain by identifying and designing value exchanges between concerned stakeholder groups. The deployment of the Value Network Analysis has been contextualized by established principles and success factors addressing the individual facilitator and the collective perception of PjBL. The value transactions are design inputs for changes and adjustments to the development stage, and for operational support instruments like the presented Facilitator's Instrument. After initial participatory prototyping with international experts, a first version supporting contextual VNA steps could successfully be tested in a course on Digital Twin generation, but has to be improved, both in terms of inputs and user experience. Further cases will show whether this kind of instrument provides added value to the development of facilitators in the context of PjBL.

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