Using Formative Assessment and Feedback to Train Novice Modelers in Business Process Modeling

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***Abstract*—Process models play a vital role in modern businesses, specifically in the software development lifecycle to (re)design and (re)engineer business processes. There exists a large body of research on classifying errors in business process modeling (BPM) and on the importance of higher-quality process models in the early design stages. Some works have defined quality frameworks and listed guidelines for modeling to help modelers achieve higher-quality diagrams. But there is no established way in which BPM should be taught, and there is a research gap in connecting instructional design and BPM. The current study addresses this gap by presenting a teaching module on BPM at a higher education institute in blended learning contexts. To improve the skill sets of novice modelers it is crucial to teach them how to interpret and integrate quality into BPM by giving them feedback on errors they make. We achieve this by leveraging pedagogy, incorporating formative assessments and an error typology.**

***Index Terms*—Teaching BPM, Feedback on errors, Formative assessment, Formative feedback, Learning report**

I. Introduction

Process Modeling (PM) plays a crucial role in contemporary businesses, particularly in software development life cycles and in the (re)-design and (re)-engineering of processes. Since the use of low-quality models in the initial stages of design can have harmful effects [30] and prove to be highly costly during subsequent design phases [37], process models must adhere to a set of rules defined by the modeling grammar. This adherence ensures the syntactic correctness of the models, emphasizing the importance of maintaining their syntactic quality. Furthermore, process models should be complete in terms of requirements, incorporating only accurate and relevant statements that pertain to the domain [33], thus providing semantic correctness. Novice business analysts will be placed at an advantage in organizations if they have developed strong modeling skill sets during their university education.

PMPMIn the domain of PM, while there are several studies on PM comprehension [9], [17], [22], [28], and guidelines on modeling offered for novice modelers [2], [3], [12], [27], studies on how to teach PM are quite rare. A recent literature review on conceptual modeling in education [31], focuses on studies to explore the complexities of learning conceptual modeling for novice modelers. This review reported on several methods and pedagogical resources, encompassing 121 published papers from 1986 to 2017. The review revealed a limited emphasis on PM, accounting for only 8% of the included studies. While feedback emerged as one of the extensively researched themes, there is a scarcity of studies demonstrating the practical implementation of feedback to teach PM in blended learning (BL) course contexts and there has been relatively less attention in terms of research devoted to teaching methodologies. To the best of our knowledge, there have not been any studies on identifying specific learning objectives (LOs) in teaching PM, emerging patterns of errors by novice modelers, and linking them to higher levels of Bloom's Taxonomy [24] within a BL course context.

Recognizing this research gap, there is a growing need to focus on developing effective instructional strategies, frameworks, and guidelines specifically tailored to teaching PM. Such research efforts can contribute to the advancement of pedagogical knowledge in PM education and provide educators with the necessary tools and techniques to effectively teach crucial aspects of Business Process Management (BPM). The teaching of PM holds a prominent position on research agendas in the field of PM discipline [18], [31]. Proficiency in PM is crucial for effectively managing or automating business processes. However, learning PM presents challenges due to its inherent complexity, which requires specific cognitive frameworks and practical experience [34]. Improving the training of process modelers can contribute to the acquisition of the necessary skills for PM, potentially addressing the prevalent issue of subpar process model quality within organizations [9].

In this paper, we present a flexible PM module as a facile example for educators, with the aim of unraveling the complexities involved in teaching PM to novice modelers.

When designing the PM module, several crucial decision points were taken into consideration to ensure alignment with pedagogical principles, existing research, and available PM educational resources. Further, specifically for the learning materials at the highest Bloom level (Create) that involve practicing modeling, feedback on errors was offered. The present work dwells on the mode of feedback, the quality of feedback, and how possible improvement in both learning instruction and feedback can be identified from the current exploratory error analysis.

II. Background

A. Quality of Process Models and Guidelines on Modeling

Several frameworks and guidelines have been proposed for process model quality (PMQ) to reduce errors and provide metrics for assessing process model quality. Notable frameworks include Guidelines of Modeling (GoM) [3], seven PM guidelines (7PMG) [27], and Quality of Process Models (3QM) [29]. The comprehensive PMQ framework proposed in [13] discusses various existing frameworks and emphasizes the significance of syntactic quality as the only metric that can be directly observed and objectively measured. GoM presents six generic guidelines for PM, but lacks specific metrics for measurement, making it less practical for non-experts. 7PMG addresses this limitation with user-friendly indicators for novice modelers, although it may have a narrower scope. 3QM builds upon earlier frameworks and offers comprehensive metrics and measurement procedures for assessing process model quality. Additionally, other guidelines and metrics have been developed to focus on specific aspects of PMQ, such as model complexity [36], understandability [12], and process model comprehension [15]. In order to teach novice modelers and assess their understanding of modeling, it is essential to train them on the best practices of modeling. With more than eight years of teaching the BPM module in multiple courses, the teaching team incorporated guidelines from several of these references mentioned here.

B. Errors and Feedback for Modeling Education

Business Process Modeling is often prone to both syntactic and semantic errors. Bolloju and Narasimha [8] propose that novice modelers can improve the quality of their conceptual models by being aware of common types of errors and receiving feedback during the learning process. Novice modelers tend to make similar errors in learning modeling and error persistence even at higher levels of proficiency [5]. These can be avoided with appropriate feedback right from the start.

The Hattie and Timperley feedback model [21] suggests that feedback should address fundamental questions (i.e., ”what” and ”how”) to guide students in achieving the LOs and understanding the steps necessary to reach them. To this end, Bogdanova [6] takes a step further by categorizing errors by novice modelers in domain modeling into an ontology; and aligns the LOs and errors with Bloom’s taxonomy in aiming to enhance pedagogical effectiveness. In a series of papers [5]–[7], Bogdanova impresses on the course of action to be taken in achieving this through a semi-automated tool that generates personalized feedback reports for student-submitted models.

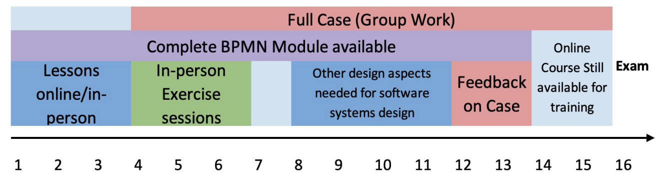

Fig. 1. Course timeline in weeks

However, providing personalized feedback for every modeling exercise can be challenging for instructors in HE, particularly when dealing with large student cohorts.To address this challenge, alternative approaches such as group feedback sessions, online feedback, or just-in-time teaching have been proven successful in various educational settings. These approaches provide valuable alternatives to personalized feedback and can effectively support learning processes. Moreover, within the PM domain, while modern modeling environments offer verification support that can automatically identify certain errors [35], there is still a lack of sufficient support, especially for errors related to semantics. Recognizing this gap, Haisjackl et al. [20] conducted an exploratory study on how humans inspect process models. The study highlighted the importance of adopting a systematic approach to model inspection, through the implementation of test-driven development and the use of automated checklists. This systematic approach can help address the need for comprehensive support in identifying and rectifying modeling errors.

A framework called Model Judge was proposed in 2019, using the full power of Natural Language Processing and optimization techniques to validate models and provide diagnostics to learners regarding the syntactic, semantic, and pragmatic quality of drawn models [32]. On the Model Judge platform, learners can draw their models on the interface (powered by Camunda) and check their diagrams against the textual description at several stages of the designing process with the potential to improve process quality. The authors as instructors find that this could be an exceedingly useful tool for instructing students but it does not include specific LOs and pattern finding that is vital from the teaching perspective of this particular course. As existing tools or frameworks did not satisfactorily fit into the current study, an error ontology was created with Individual Errors and Patterns based on the most commonly accepted modeling framework proposed by [25] for its ease of use. See more in the methodology section.

III. Course Design

A. Audience & Course Setting

The BPMN module was designed as a part of an optional course on “BPM and Software Systems Design”(BPM&SSD) followed by students enrolled in the second semester of a one-year Master in Business Administration (MBA). The MBA program is offered both in English and Dutch at the Business

TABLE I
COURSE ORGANIZATION

OLA	Main learning Activities	ECTs	SA	BPM part in SA
Part 1	Lessons, quizzes, practical exercises	3	Written Exam 10 points Individual Exam	5 points
Part 2	Solving a real case in a group	3	Case Report 10 points Group assignment	5 points

Faculty of a Belgian university. The students enrolled in this academic Master's have commenced this program after completing either an academic Bachelor, a bridging program after a professional Bachelor, or another Master's degree (See [1]). The students following this course are considered novice modelers with very little or no prior modeling experience.

B. Course Organization

Table I outlines the course organization into two separate educational activities or parts - (1) Part 1 - learning the techniques of designing PM and the details needed for the design of software systems through theoretical and practical sessions and (2) Part 2 - developing the Case (Case). Each part holds 3 ECTs, each with a separate specific Summative Assessment (SA). In the first part, techniques for BPM are taught along with the depiction of common software systems like ERP, SRM, etc., found in organizations. The necessary tools required to design software systems e.g., presenting use cases, making cost estimations of the project, structuring databases, etc. are taught. The SA for this part is a written test consisting of multiple-choice, open, and closed questions adding up to 50% of the total score (10 out of 20 points). The second part consists of an assignment (Case) in which the students work in groups on a company project. They face an unstructured context of information needs and translate this into a structured report depicting processes (using BPMN), and other elements, proposing a database design and cost estimation. The result is presented to the client (a company or organization) and defended orally during the exam period. A Case report is the SA for the remaining 10 points. In both the SAs, there is high weightage with 5 out of 10 points in each part for modeling processes. In the rest of the paper, we focus solely on the PM content of this course - the BPM learning module containing the learning items (lessons and formative tests), the modeling questions on the written SA (5 points), and the modeling part of the SA Case report (5 points).

C. Learning Objectives & Blooms Taxonomy

In designing the BPM learning module, we enforced the scaffolding levels of Blooms Taxonomy as described by [4] for domain modeling, applying the revised Bloom levels of educational objectives [24] to PM. Primarily, the SAs of the course identified at the highest cognitive level of "Create" was taken into account when the learning content was designed. For the BPM part, both in the SA Written exam and the Case report, the students are asked to model a given textual description of processes using BPMN needing an expert level of familiarity with PM. The LOs and the content were classified into different Bloom levels. The formative assessments (FAs) consisted of FA quizzes at lower Bloom levels (Understand, Analyse, Evaluate) as compared to PM FA exercises at the highest Bloom level (Create) similar to that of the SAs.

To establish the relevance of considering Bloom's levels for FAs, a preliminary correlation analysis was performed (not showcased here) between the SAs vs. FA quizzes and FA exercises. For an SA at a high Bloom's level, the corresponding FAs at higher Bloom levels are more correlated. This result showed the usefulness of utilizing FAs at the same Bloom level as the SAs and looking more closely at the LOs of the FA exercises. To this end, the instructors were particular that the main LOs of the course are for the students to detect and design different Individual Elements and Patterns from textual descriptions. Each FA exercise was chosen such that sequentially, the students encounter from the lowest difficulty level, with the first exercise having only one decision point and with most of the later exercises having several Advanced elements and Patterns to be modeled.

D. Modeling Tool Use

Visual Paradigm was used as the modeling tool for its flexibility in drawing process diagrams and in other functionalities necessary for making the Case Study. It does not offer extensive feedback on syntactic errors, unlike other tools like Signavio or Camunda. While these tools may provide feedback on syntactic correctness, and identify incompleteness utilizing meta-models and static semantics, one of the authors who uses Signavio in another course on modeling, observed that students often ignore the suggestions made by the tool.

E. Proposed Format

The course is designed to follow the flipped classroom principle with the theoretical sessions furnished as pre-recorded online material for the students to follow at their will and their own pace. The in-person sessions are devoted to practical exercises, interaction with the teacher, feedback, and seminars from industry experts. In lieu of the university's response to post-pandemic circumstances and culture, where a reduced number of students attended in-person classes but took the exam; most of the learning material was also required to be available online asynchronously. The complete course timeline is depicted in Figure 1.

F. Learning Content & Mode of Delivery

Following the literature studies and books on the BPMN notation [10], [11], [16], the BPMN learning material has been organized into two main sections: BPMN Basics and Advanced. These sections were thoughtfully structured and included specific fixed content items, such as lessons and practice exercise sessions. The course design and delivery modes facilitate the proposed format in the following way: Lessons were planned as videos with each video having a central focus on specific BPMN concepts. Interspersed between the 4 BPMN Basics and 7 BPMN advanced videos, 6 FA quizzes, and 8 FA exercises were planned to help the student with self-evaluation and self-regulation. The FA exercises were set up with increasing levels of complexity and knowledge to be sequentially solved in a specific order following the introduction of new elements in BPMN in the lessons. These learning items were also offered online giving autonomy to the learners to pace themselves and to work on it at home in case they cannot come to class.

G. Formative Assessments, Feedback, and Adaptive Release

Beyond evaluation and measuring the effectiveness of learning, assessments can motivate, activate, and help students self-regulate and achieve their learning goals [26]. Two types of FAs are used in the BPM module - 6 Quizzes and 8 Exercises. We focus primarily on the FA exercises in this study. Incorporating feedback into the teaching and learning processes and its influence on the learning outcomes in different learning (traditional, blended, or online) contexts have been well-established in the extant literature [14], [19], [23]. For training the students in modeling, high value was attributed to giving feedback on their solutions through in-person sessions for solving the exercises. During exercise sessions, at first, a few exercises were solved step-by-step to introduce how a textual description can be interpreted and a process diagram be realized. Students are given time to solve more exercises by themselves, and the instructor and teaching assistant help with individual difficulties and give group feedback. Possible solutions, good modeling practices, strong emphasis on common difficulties and errors are discussed for each exercise at the end. This is done to facilitate discussion and aid students improve the quality of their models. From previous research, [4] reflecting on resources and exercises for teaching modeling, and verbal feedback received from students over the years, great attention was paid to the list of exercises offered in the course through the in-person exercises sessions and the FA exercises. They were chosen/created such that the difficulty level of the exercises was increasing, and covered all main elements and concepts covered in the lectures. In total 23 exercises were seen in the course with 8 of them as FA exercises on the LMS.

The feedback element on solving exercises is also added to the learning content available online asynchronously for the FA exercises. Feedback on the common mistakes and (specifically semantic) errors in the solutions has been offered in feedback videos which become available via adaptive release when an FA exercise is submitted on the LMS. The adaptive release of learning material was chosen to motivate and activate students to solve the FA exercises before consulting the solutions directly. Each FA exercise was mapped to specific LOs. See Table II for examples of LOs mapped to a few exercises. Each of the exercises labeled 1 to 8 was presented sequentially in the course presentation. So the students would have to attempt them chronologically. Over time, newer concepts were introduced and the level of difficulty of the exercises increased requiring to employ new knowledge of elements taught in the lessons.

TABLE II
LINKING LEARNING OBJECTIVES AND FORMATIVE ASSESSMENTS

Learning Objectives for Detecting and designing	Ex_02	Ex_04	Ex_06	Ex_08
Individual Elements:				
Activities, sequence flows, start/end events,	x	x	x	x
Pools and lanes, messages, message flows	x	x	x	x
Gateways - XOR, AND	x			
Gateways - Inclusive OR			x	
Gateways - Event-based			x	x
Patterns:				
Deadlines		x	x	x
Request-response synchronous	x		x	x
Process scope			x	x

IV. METHODOLOGY & ERROR TYPOLOGY

A. Data Collection

The participants in this study are all the students enrolled in the course BPM&SSD. The student submissions to the 8 FA exercises were collected from the LMS grade center for error analysis. Additional information on the submission of exercises and the feedback videos watched were collected from the log data for the LMS. According to the log data, there were 160 attempts for the 8 FA exercises. However, the extraction from the grade center only presented 92 BPMN diagrams which were either submitted as jpeg, png, pdf, or vpp files. This drop in numbers could be perhaps because the students used the wrong file formats for submission or did not complete the submission correctly. Among the submitted files, wrong uploads (e.g. same file submitted for all exercises, other files uploaded, etc.) were filtered, leading to a final number of 80 diagrams to evaluate.

B. Correcting Process Modeling Exercises

Three evaluators assessed the quality of these submitted models. Two were members of the teaching team (one professor and a teaching assistant) and one BPM researcher. The first few diagrams were corrected together with discussions on the errors, solutions, and definitions so as to maintain reliability across evaluators. Each evaluator checked the corrected models and errors marked by the other evaluators to validate consistency. The evaluators manually corrected these diagrams with an emphasis on whether LOs were being met or not. The names and definitions of the errors were discussed. Each error was named using the combination of the *Specification* (Missing/Wrong/Obsolete) and the *Error Source* (a particular Individual Element/Pattern) related to the LOs. Each error was captured including each occurrence of the error in each model (per student, per exercise) adding up to a final error list.

C. Typology of Errors

As reported in section II-A, error classification into groups has been investigated and reported on PM comprehension and quality research. However, how the feedback on these errors should be given to novice modelers is rarely clarified. Quite typically the errors made by the novice modelers do not strictly follow these classifications. In the current study, a structured bottom-up approach was used in constructing the complete list of errors and categorizing them. Next, in order to extract actionable feedback for students, the errors were classified into the below-mentioned dimensions beyond just the widely used syntactic and semantic categorization.

1) Semantic vs Syntactic: The first categorization was based on existing literature as mentioned in section II-A. While Syntactic errors refer to the formal syntax of the model: mainly, the modeling notation; Semantic errors are those related to the validity and completeness of the model. Each error is bagged into Semantic or Syntactic categories. Pragmatic errors are those that hinder comprehension or affect the executability of the model, with the focus of this study more on learning and less on execution, we don't consider pragmatic quality included in the scope of this study.

2) Individual Elements vs. Patterns: The principal LOs for this teaching module are to understand the textual description of the process and to detect and design models from it. From the text, the learners are expected to detect not only Individual Elements but also specific Patterns to be modeled. Designing a pattern involves many Individual Elements coming together to make a specific combination. A pattern can be present in several contexts (in several exercises) and on recognition, it can be modeled using one or more predefined solutions (usually containing a group of elements). Some of the Patterns taught as part of the LOs of the exercise sessions and the FA exercises relate to the modeling of (1) deadlines (involving event-based gateways, racing events, or a receiving message task with boundary events), (2) treatment of a batch of instances (requiring loops, dealing with individual instances, subprocesses with tasks, decision points), and (3) request response Patterns (collaboration between pools), etc.

Making a mistake in understanding and recognizing particular elements from the text will result in an Individual Element error. Errors in recognizing and modeling Patterns could result from (1) mistakes in one or more corresponding Individual Elements, (2) mistakes in connecting the corresponding Individual Elements, or (3) correctly using Individual Elements syntactically but not capturing the pattern itself. Lastly, there can also be errors like 'implicit ending', 'deadlock', etc which did not originate from the LOs of the module but arise due to process properties. We classify these as Patterns, as they cannot be detected without looking at the process as a whole.

3) Basic vs Advanced: As mentioned in the section III-F, the modeling notation (BPMN) was introduced/taught as Basic and Advanced sub-chapters containing several basic and advanced Elements and Patterns. Using the *Error Source*, each error was placed into these binate Basic and Advanced labels.

4) Priority Levels: When grading the modeling questions in the SA, there have to be specific metrics necessary to award or reduce points assigned for the exercise. Even though the FA exercises are not scored but are meant for practice and delivery of feedback, the teaching team reflected on which of the errors were of more priority than others. Scoring on the SA was scrutinized and the priority of the mistakes/error was applied to the submitted FA exercises. Errors were categorized also into low, mid, and high-priority levels based on the LOs for each exercise. Basic notions such as style errors are low priority, comprehension of text issues is mid-priority, and inability to model Patterns are high-priority.

TABLE III
EXAMPLES FROM THE ERROR TYPOLOGY WITH APPLIED CATEGORIES.

Syntactic /Semantic	Individual Element /Pattern	Priority	Basic /Adv	Specification	Error Source
Syntactic	Individual	high	Basic	Missing	Gateway
Syntactic	Individual	mid	Basic	Missing	End event
Semantic	Individual	low	Basic	Missing symbol	Task
Semantic	Individual	high	Adv	Obsolete	Event Based gateway
Semantic	Pattern	high	Adv	Missing	Batch (Loop)
Semantic	Pattern	high	Adv	Wrong	Batch (Loop)

5) Design vs Labeling - Individual Elements: For each Individual Element that is expected to be modeled, the two-fold objectives are to care for the design of the element itself and correctly label it. Labeling errors were captured within the error names, in the *Specification* part (e.g. Missing label - Task, Wrong label - Event). At first, labeling errors were marked and recorded along with Design errors. They occurred in most of the exercises but they were exceedingly many for specific exercises (e.g. when Exercise has a LO of communication between pools). It was noticed that students not only missed the labeling of messages but start/end events consistently through exercises, and used the wrong name conventions and missed mentioned task types. The teaching team reflected that the FA instructions did not explicitly mention labeling even though it was mentioned as a good practice in the lessons multiple times. In addition, when scoring a diagram in the summative assessment, these labeling errors have the lowest weight. Lastly, as none of the students used labeling on the summative written exam and case report, this syntactic group of errors was dropped from the complete list.

D. Analyzing Errors

As each solution to an exercise depends on the degree of abstraction or granularity, some errors may be specific to one exercise. The following steps were followed to capture common errors across exercises. For every diagram submitted by the student, each distinct error and the frequency of occurrences in the diagram are captured. Also per exercise, the number of students committing one distinct error is captured. Next, a complete list of errors in all exercises was put together. To summarise results, the total frequencies per exercise and the total number of students committing a distinct error are listed together for comparison. Lastly, occurrences of an error across exercises are also captured. The number of errors in different categories is reported and compared in the results and discussion sections.

V. Results and Discussion

The key result from this study is the formalization of errors typology IV-C done to allow for meaningful analysis of the student learning and for designing the BMPN module. We show a few examples with the typology in Table III. Each row contains one error, named with the combination of the *Specification* level and the *Error Source* and how it is categorized under different dimensions. 44 types of unique errors were identified, with a total of 207 errors. From all these errors, about 60% (125) are on basic elements of BPMN, while the remaining 40% (82) are on advanced elements. The 42% (87) of the errors are syntactic in nature, while the remaining 58% (120) involve aspects related to semantics. As the error typology included more of the semantic category than syntactic, it was expected that overall frequencies of semantic errors would be higher than syntactic. Figure 2 shows the frequency of syntactic and semantic errors. Counter-intuitively, syntactic errors had a higher frequency than expected as students made the same syntactic error multiple times in a diagram increasing the frequency. Each FA exercise had specific learning outcomes for distinct Individual Elements and Patterns as shown in Table II with the exercises increasing in complexity (and Patterns) from Ex1 to Ex8. This is perfectly reflected in Figure 3 where the percentage of errors in Patterns increases as compared to those of Individual Elements.

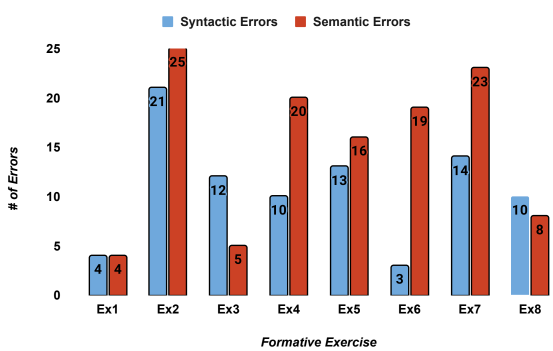

Fig. 2. Syntactic/Semantic error numbers in FA exercises

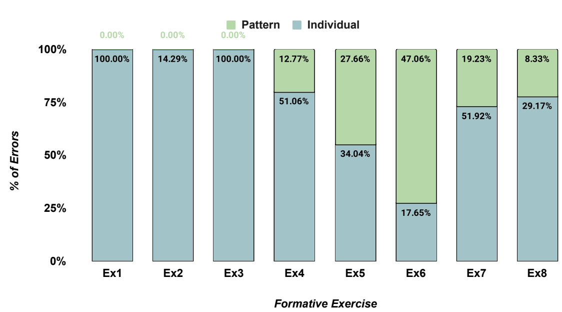

Fig. 3. Individual Element and Pattern error percentages in FA exercises

For the Basic vs Advanced dimension, (see Figure 4 we see that students continue to make mistakes in Basic elements

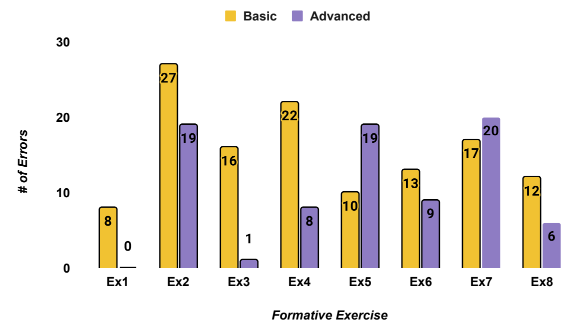

Fig. 4. Basic/Advanced error numbers in FA exercises

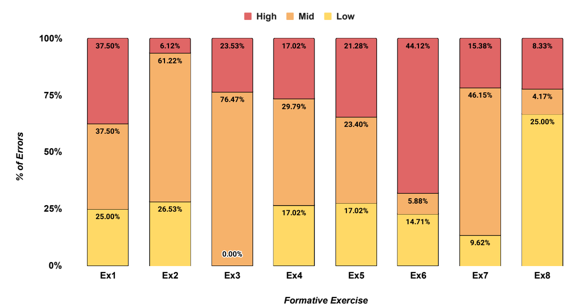

Fig. 5. Priority-based error percentages in FA exercises

of BPMN across all exercises. In the later exercises, there are more Advanced category errors. As the complexity of exercises increases, more Advanced elements and Patterns are required to be modeled in the later exercises, and hence we see a decrease in the percentage of Basic errors. This decrease could possibly also be an effect of feedback offered through videos and in-person and during exercise sessions. Figure 5 shows the error percentages for the priority dimension with no specific trends on low, mid or high priority categories. Figure 6 shows the distinct errors made per student per exercise and the four curves indicate the major *Specification* categories: Missing, Wrong; paired with the LOs of modeling a Pattern or an Individual Element. The context of each exercise differs in the particular number of Individual Elements and Patterns to be detected and captured in BPMN diagrams affecting the type and number of errors per exercise. We see that there are no Pattern errors (both for Missing or Wrong specifications) in Exercises 1-3, as these were simpler exercises and there were no Patterns to be modeled. Particularly, notice that for Exercise 4 there are more Wrong Element errors committed by students, and Exercise 7 has a high no. of Missing/Wrong Element errors. For example, Exercise 4 is the first exercise where complexity increases and Patterns have to be recognized. Notice that Wrong Element being use drops in the next two exercises until Exercise 7 which has higher complexity.

To summarise, considering the complete list of errors, the frequency of the errors, and the visuals presented above, the outcomes of this analysis as follows. Firstly, within the

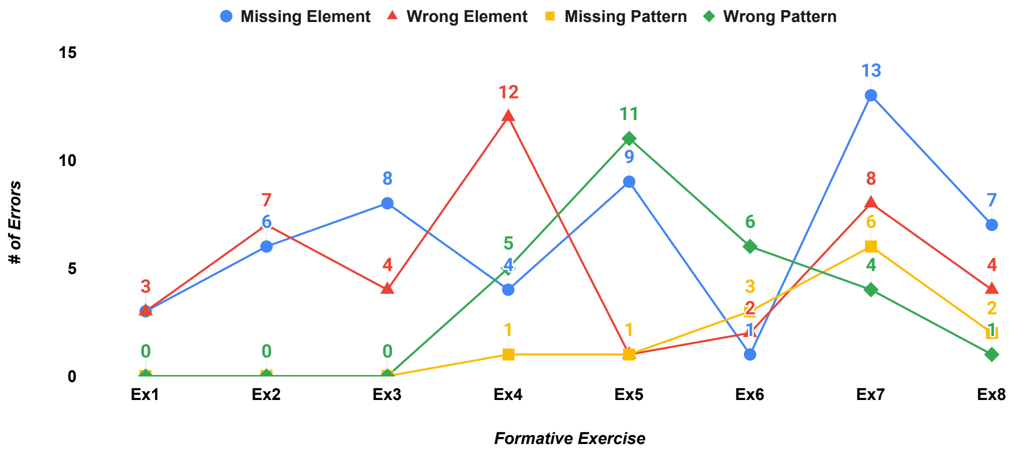

Fig. 6. Number of distinct errors (per student, per exercise) based on Specification and LOs.

error topology itself, the trends emerged helped to optimize the assigned categories in a second iteration. For example specifically in the Priority dimension: (1) When an *Error Source* belongs to the essential BPMN elements, the priority is high. Every model needs to have the basic elements (basic: start, end, task, event, decision point, pools, and lanes that should be modeled. Missing these or modeling them wrongly results in high-priority errors. (2) The priority is strongly dependent on the earlier classifications: (a) as Patterns involve a group of elements, a pattern error is always a high priority; (b) high-priority errors are more semantic vs. syntactic; (c) The labeling errors are mostly low priority (as they have low weight on scoring) compared to design errors which have low-high priority. (3) In specific cases, some errors have a range of priority based on a certain criterion. For example for the error "Missing Sequence Flow", the criterion is disruption - priority is low when it is an obvious (harmless) miss and high when it clearly disrupts the process (harmful) and does not match the requirement. Overall, this typology has the potential to be extended to include more LOs, *Specifications*, Individual Elements, or Patterns. It can indicate which feedback can be highlighted, which learning material could be improved etc.

Secondly and more importantly, we gain insight into what are the most common mistakes in each exercise, and the priority of these errors with respect to evaluation, and this can be communicated to students effectively. Thirdly, paired with the data on the Priority dimension, and identifying common mistakes makes it possible for instructors to highlight these errors to students through the feedback videos (which can be updated) and in-person sessions through group feedback. In addition, based on the number of students making errors in specific Patterns can indicate to instructors for which particularly difficult concepts, the time spent in explaining be increased. Instructors can reflect on the content of these exercises and what feedback and instruction can benefit students. Lastly, the teaching team would like to note that designing the module with video lectures and developing the online FA exercises required considerable effort in the initial iteration but in the later iterations of the course with only minor changes or updates. Nevertheless, the delivery modality allows students to access the course contents completely whether or not they come to class.

A. Limitations

This work is an exploratory study with several limitations. The number of FAs is low with exercises having diverse learning objectives. This is a serious limitation as it allows only a reflection on improving the feedback but does not actually measure the effectiveness of the proposed feedback. This could be rectified by having two iterations of exercises interspersed with feedback on modeling. On one hand, with declining numbers in live lecture attendance and procrastination in studying materials of the course, as the FA exercises were only offered optionally to students, on average only 11 out of 43 students provided an actual solution per exercise. It is possible that with a larger sample of student solutions, the error ontology will expand. On the other hand, as this analysis was conducted at the end of the course run, student perspectives could not be included about the utilization and use of FAs in the course. These could be planned in the next course run. As there is no standardized way of assessing the student modeling skill, particularly in courses teaching BPM, the checking process strongly depends on the instructor's perceptions, perspectives, and idiosyncrasies. This could be a strong influence on the Patterns and errors found. Moreover, the very process of checking complex models is subject to objective criticism. It would be more comprehensive to interview other teaching teams of PM to collect several teacher perspectives on grading student submissions.

VI. Conclusion

This paper reported on (1) how a facile teaching module can be created for BPM connecting instructional design and teaching PM in a BL context; (2) the possibility of giving feedback on common mistakes and errors in modeling through both feedback videos (online asynchronous) and feedback moments (online and in-person synchronous) to bolster student knowledge; and (3) an exploratory error analysis on models submitted toward FAs by Master's level students following this module. In this presentation, we limited ourselves to a simple analysis and categorization of errors in finding insights. These insights can be used to improve the course material and feedback given on errors in the next runs of the course thereby helping students understand what they are doing wrong and how can modeling be improved. Due to the blended, facile nature of the course design, it provides several opportunities to further deepen the analysis by giving a second set of FAs with the same LOs as those discussed in this study to measure the effectiveness of feedback. Another direction of future research is to formulate an extensive scoring system to correct the FAs and formalize it with the grading system followed in the SAs as well. We hope that the results and discussion on the use of FA exercises and error ontology in improving feedback will serve as inspiration to incorporate feedback and FAs in creating structured, pedagogically aligned, and, mature learning modules on PM in BL flexible formats.

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