

# A Business Process Metadata Model for a Process Model Repository

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**Abstract.** Today reuse of business process models is becoming increasingly important. One of the proven solutions for reusing business process models is the use of repositories. Repositories should have process models and process metadata that can help users in searching, understanding, and interpreting process models. The purpose of this paper is to propose a Business Process Metadata Model (BPMM) that would facilitate a) locating process models, b) understanding and/or interpreting process models, and c) navigating a process model repository. In order to evaluate the BPMM, an empirical study is conducted to measure consistency and correctness of annotating business processes by using BPMM.

## 1 Introduction

Business Process Management (BPM) has become one of the most important instruments that help modern organizations meet their business goals and achieve competitive advantage. Business process modeling plays a vital role in BPM. Motivations for modeling business processes include documenting current business processes, redesigning and improving processes, aligning business and IT, etc. While modeling of business processes remains a complex, costly and time consuming task [1, 2, 3], the efforts made to model business processes are seldom reused beyond their original purpose. Reuse of process models can reduce the cost and complexity of modeling business processes from scratch [3, 4].

A business process model repository is one of the proven approaches for supporting process models reuse [5, 7]. The repository provides a central location for storing, managing and changing process knowledge (business rules, relationships, process elements, etc.) [5, 6]. In addition, a repository enables stakeholders to retrieve process models for various purposes like understanding, updating, simulating and analyzing process models.

Reuse of process models cannot be done literally because it involves searching the process repository to find suitable models that can be the base for a new design. Therefore, the stored process models must be well described and classified to facilitate searching and interpretation. It has been argued that the use of process metadata and/or business context can meet these requirements [7, 8, 10, 11, 27]. Also, recent studies [9, 10] affirm that characterizing business processes facilitates understanding and navigation. However, only well structured metadata can increase the likelihood to

properly understand and reuse business processes. Therefore, the aim of this study is to propose a business process metadata model (BPMM) for annotating business processes to facilitate locating, interpreting process models and navigating the repository.

The remainder of the paper is organized as follows. In section 2, we present the method used to develop BPMM, followed by a detailed description of the model. In section 3, we introduce an empirical study to evaluate BPMM by measuring annotation consistency and correctness. Finally, in section 4 the lessons learned and limitations of the study are presented.

## 2 The Business Process Metadata Model (BPMM)

In this section, we present the Business Process Metadata Model (BPMM) that can be used for annotating process models in the process model repository. The BPMM intends to facilitate: a) locating process models, b) understanding and/or interpreting process models, and c) navigating a process model repository.

The BPMM has been developed based on a systematic approach, which consists of three phases, identification of process related concepts, validation of the concepts and the model construction. Due to space limitations, we briefly describe the phases and the results.

**Identification of Process related Concepts.** In this phase a set of process related concepts (in this paper they are also referred as concepts) were collected by considering established business frameworks, process classification schemes and business process perspectives as inputs to an analysis and subsequent synthesis. The identified concepts include, a) *process description* b) *business context* as defined by [12], c) *business goal* from business process perspectives [13, 14], d) *domain specific classification scheme* based on [10, 16], e) *generic classification scheme* based on [10, 16], f) *process property*, g) *resource* and h) *actor* from REA [17, 18] and the process design framework [19], and i) *process relationship* [16].

**Validation of Concepts.** In this phase the identified concepts were validated through an empirical study which involved 25 volunteer participants. The participants included researchers and practitioners who participated in the 2<sup>nd</sup> *Working Conference on the Practice of Enterprise Modeling* (PoEM'09) [20]. The participants were asked to assess whether annotating business processes with these concepts would facilitate searching, navigating and interpreting process models in a repository. A scale of 1 to 5 (from strong disagree to strongly agree) was used to validate the concepts. The results of the study are shown in fig. 1. The figure shows that a large number of participants agree (either agree or strongly agree) with most of the concepts.

**The Model Construction.** In this phase corresponding metadata elements of the validated concepts were defined. This was followed by defining relationships between elements and a business process.

*Business context*, *goal*, *resources*, *actors* and *process relationship* from the validated concepts were directly included as elements in BPMM. From the generic classification scheme (a concept) the following elements are defined: *process area* (based on Porter value chain [21]) and *process phase* (based on Open-EDI [22]). In addition

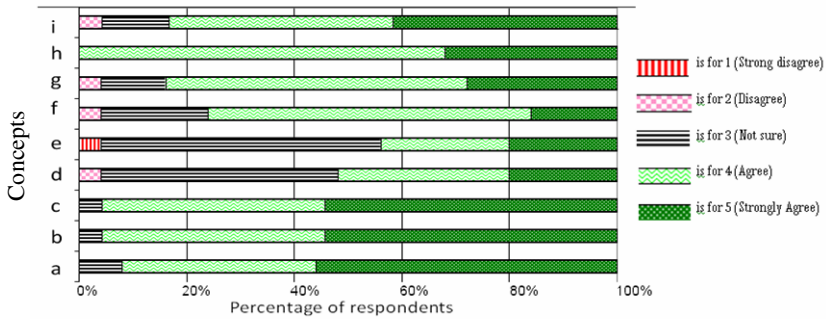


Fig. 1. Validation of Concepts

to that, we have introduced two more elements that do not have direct relationships with any validated concepts. However, these elements were derived from the participants' feedback and their references to different studies [17, 18, 23]. These elements *are process type* (based on REA framework [17, 18]) and *process level* (based on Organizational Theory [23, 24]).

Domain specific classification schemes were not included because the repository is intended to include processes which are not limited to a specific domain. Furthermore, widely accepted classifications for several domains are not available, e.g. a classification scheme for supply chain (SCOR [25]) is available, whereas an equally accepted classification for healthcare does not exist. Furthermore, properties of processes were not included in the model, because they vary between stakeholders.

The BPMM, therefore, includes *process type*, *resource*, *actor*, *process area*, *process phase*, *process level*, *business context*, *process relationship* and *goal* as shown in fig. 2. In the following two subsections we describe the elements and their relationships.

## 2.1 BPMM Elements

In this section, we describe each element of BPMM and discuss its purpose. The central component of BPMM is a business process which is to be annotated by the elements.

**Process Area.** The *process area* is based on the Porter Value Chain [21]. In order to better understand the activities through which an organization creates value, business processes are separated into areas. The process area element classifies business processes by their function or core competence. Therefore, annotating processes with process area enables users to identify business processes based on functional area. The process area can either be primary or supporting.

The primary process areas include:

- *Inbound logistics*: A process that includes activities needed for receiving, storing, inventory control, or transportation scheduling.
- *Operations*: A process that includes activities needed for value creation that transforms inputs into outputs. These include machining, packaging, assembly, equipment maintenance, testing and all other value-creating activities that transform the inputs into the final product.

- *Outbound logistics*: A process that includes activities required getting the finished product to the customers: warehousing, order fulfillment, transportation, and distribution management.
- *Marketing & Sales*: A process that includes activities associated with getting buyers to purchase the product including channel selection, advertising, promotion, selling, pricing, retail management, etc.
- *Service and Maintenance*: A process that includes activities that maintain and enhance the products value, including customer support, repair services, installation, training, spare parts management, upgrading, etc.

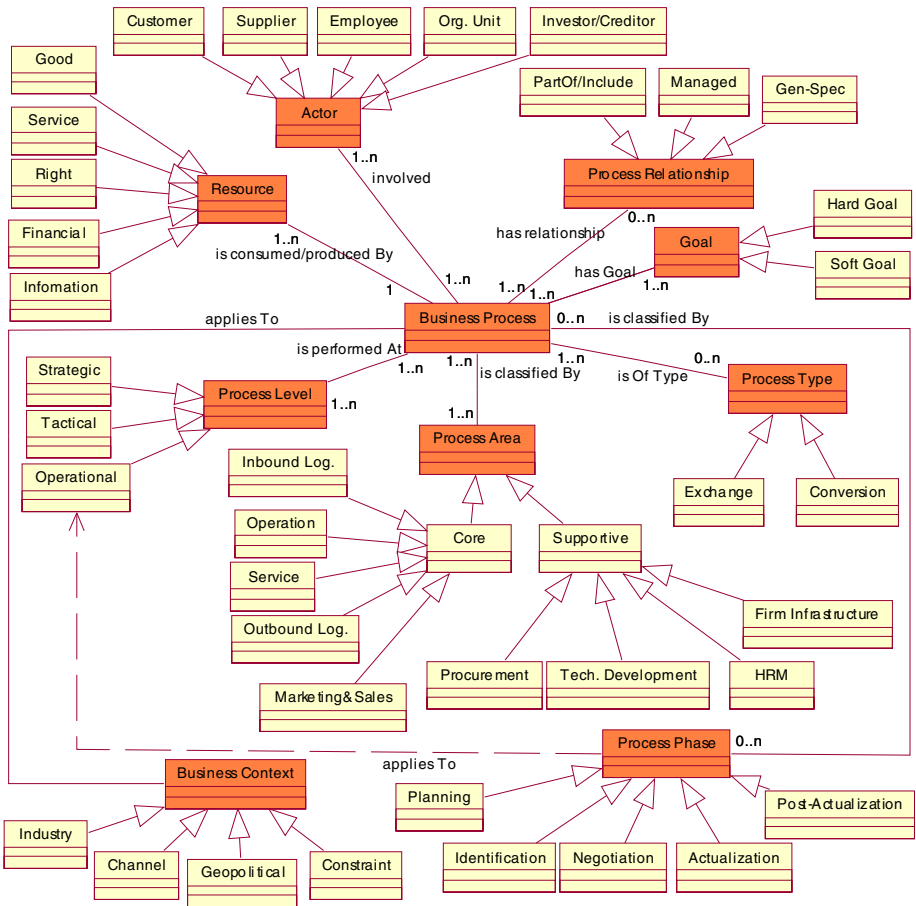


Fig. 2. The Business Process Metadata Model (BPMM)

The supporting process areas include:

- *Procurement*: A process that includes activities needed for acquiring raw materials, services, spare parts, buildings, machines, etc. These include information gathering on resource needs and supplier offerings, supplier contacts, background reviews on the quality of supplier offerings, negotiation, fulfillment, and supplier performance evaluation.
- *Technology Development*: A process that includes activities that support the value chain activities by developing new technology and procedures, such as Research and Development, Process automation, design, and redesign.
- *Human Resource Management*: A process that includes activities associated with recruiting, development (education), retention and compensation of employees and managers.
- *Firm Infrastructure*: A process that includes activities related to general management, planning management, legal, finance, accounting, public affairs, quality management, etc.

**Process Phase.** A business process can be constructed from a set of operational activities. In order to serve as a basis for co-ordination of work between different partners (in business collaboration) open-EDI [22] classifies these activities into five phases. The *process phase* element is based on the open-EDI. It defines the phase(s) to which a business process belongs. Therefore, annotating business processes with this element enables users to identify business processes based on the phases. The process phases are:

- *Planning*: The planning phase includes all activities needed to decide what actions to take for acquiring or selling goods and services. Here actors are concerned with the question of what goods or services to acquire or sell.
- *Identification*: The identification phase includes all activities needed to identify, select, and establish linkages with partners that are involved in the business collaboration. The question is with whom to do business.
- *Negotiation*: The negotiation phase includes all activities needed to establish a contract (agreement) and related commitments for the exchange of goods and services.
- *Actualization*: The actualization phase includes all activities needed to prepare and perform the resource exchanges stipulated in the contract established in the negotiation phase.
- *Post-Actualization*: The post-actualization phase includes the follow-up activities of resource exchanges performed in the actualization phase, e.g. warranty coverage, complaint handling, and after-sales service.

**Process Type.** Resources are produced and/or consumed through a series of business processes. The *process type* element classifies business processes around the resource life cycle, i.e. from acquisition, conversion to delivery of goods and services. The process type is based on the REA framework [17, 18]. Therefore, annotating processes with process type enables users to identify business processes based on the operations performed on a resource. The process types are:

- *Exchange*: a process in which an enterprise receives resources from another actor, and it gives resources to the other actor in return. The aim of such processes is to acquire, maintain, and pay for the resources needed by the organization as well as to sell and deliver goods and services to customers and collect payment. An example is the “Sales Process”.
- *Conversion*: a process in which an enterprise uses or consumes resources in order to produce new or modify existing resources. The aim of such processes is to convert the acquired resources into goods and services for customers. The raw inputs are transformed into finished goods and services by this process. An example is the “Manufacturing Process”.

**Process Relationship.** In order to achieve business goals, organizations perform several business processes that are related with each other. The *process relationship* element describes how business processes are related. Annotating business processes with relationship information helps users to identify related processes. Furthermore, relationship information supports traceability and process change management. The process relationship may exist in the following forms:

- A *generalization-specialization* relationship exists if one process (called a specialization) is a kind-of (or *is-a*) another process (called a generalization). Example “*Manage returns*” is a generalization of “*Manage returns with prior approval*” and “*Manage returns without prior approval*”, while the latter two are specializations of the former.
- A *partof-includes* relationship exists if one process is composed of one or more processes (called sub processes). The sub process has the *partof* role and the parent process has the *includes* role. Example “*Manage order approval*” *includes* “*Handle rejected order*” and the later is a *partof* the former.
- A *manage/managed* relationship exists if one process plans, controls, monitors, evaluates, and/or designs another process.

**Process Level.** Levels are introduced in organizations in order to allow efficient management and coordination. Most organizations operate at three levels: strategic, tactical and operational [23, 24]. A *process level* element describes the level in the organization at which a business process is performed. Therefore, annotating business processes with process levels enables users to identify business processes based on organizational levels. The process levels are:

- *Operational*: A business process is said to be at the operational level if it includes activities that are performed on a day-to-day basis. The aim of such a process is to modify and exchange economic resources.
- *Tactical*: A business process is said to be at the tactical level if it includes activities that are performed on a short term plan. The aim of such a process is to manage operational level processes.
- *Strategic*: A business process is said to be at the strategic level if it includes activities that are performed on a long term plan. The aim of such a process is to define process types at the operational and tactical levels as well as the resource types to be used and produced.

**Resource.** A business process consumes, produces or transfers a resource between actors [17]. A *resource* is anything (with or without physical substance) that is regarded as valuable by some *actors* [18]. This element is inspired by REA [17, 18] and the process design framework [19]. Therefore, annotating business processes with resources will enable users to identify processes based on the type of the resource consumed, produced or transferred by a business process. In most cases, a resource fits into one of the following categories:

- *Goods:* These are the physical or tangible objects (like cars, refrigerators, and cell phones) that are of value for an enterprise.
- *Services:* These are the non-tangible resources offered by actors to increase the value of some other resources. Example haircuts, eye treatments.
- *Rights:* These are entitlements or permissions to an actor, usually of a legal or moral nature, i.e. ownership rights, usage rights, copyrights.
- *Financial:* These are funds or money (in the form of cash, cheque, voucher, credit card, etc) paid or received by an actor for goods or services being exchanged.
- *Information:* These are data in a certain context, like blueprints, referrals, and customer databases.

**Actor.** In the execution of a business process one or more actors may be involved [17]. An *actor* is an entity such as a person or an organizational unit involved in the realization of a business process. This element is inspired by REA [19, 18] and the process design framework [19]. Therefore, annotating business processes with actors will enable users to identify business processes based on the type of actor. In most cases an actor can fit into one of the following categories:

- *Customer:* An individual, company or organisation that buys goods or services.
- *Supplier:* An individual, company or organisation that provides goods or services to a recognisable customer or consumer.
- *Employee:* An individual who provides labour to an organization or another person.
- *Investor or Creditor:* A person, company, or entity that puts money or assets into an investment to yield returns.
- *Organization unit:* A subdivision or department in an organization/enterprise that is involved in a business process.

**Business Context.** ‘In practice, one and the same business process varies a little bit with respect to the business environment’ [26]. In order to reuse a process model, users may need to understand the business environment in which it is aimed to work. According to [26], a business environment can best be described by the concept of business context. A business context defines the circumstances in which a business process may be used [12]. This element enables users to identify business processes which may only apply to a specific business environment. The context in which a business process takes place can be specified by a set of categories and their associated values [12]. In BPMM we define the following contextual categories:

- *Industry*: provides the description of the industry in which the business process takes place.
- *Communication channel*: provides a description of the channel through which involved actors communicate.
- *Geopolitical*: provides a description of aspects related to region, nationality, or geographically based cultural factors.
- *Official Constraints*: describes those aspects of the business situation that result from legal or regulatory requirements.<sup>i</sup>

**Goal.** The purpose of a business process is the achievement of one or more goals. A goal is a condition or state of affairs in the world that the actor would like to achieve [13]. In order to reuse a process model, users may need to understand whether a process model achieves their business goals. The *goal* element describes the business goals which a process model is aiming to achieve. Therefore annotating business processes with goals will enable users to identify a process model based on business goals. According to [14, 15] there are two types of goals associated with a business process:

- *Soft-goals*: these are strategic goals which are more abstract objectives that an organization is striving to achieve. For example the soft goal for the “procurement process” could be “minimize procurement costs”.
- *Hard goals*: these are operational goals which define the state to be reached by a process (e.g. “complete an order”).

### 3 Empirical Evaluation of BPMM

In this section we describe an experiment we have carried out for empirically evaluating the BPMM. Specifically, the purpose of the experiment is to evaluate consistency and correctness of annotating business processes using BPMM. Furthermore, the user perception of the model is tested.

#### 3.1 Selecting Participants

The participants involved in the experiment were a mix of masters students in Engineering and Management of Information Systems (EMIS) and PhD students in Information Systems at KTH. By the time the experiment was done, all students had completed a course on Enterprise Systems and Modeling, in which they learnt basic concepts about business process modeling. The benefit of using student participants is that they form a homogeneous group with respect to their academic background and industrial experience. Furthermore, the experimental tasks did not require high level of industrial experience which justifies our selection of the participants.

#### 3.2 Preparing the Experiment

For the experiment, the following materials were prepared:

- A document defining the BPMM model and the description of each element (as presented in section 3),



- A document describing (five) business processes. In order to increase the understanding, processes were presented in both textual and graphical form. Annotating business process is a time consuming task, therefore to keep the participants positive to the experiment, we had to limit the number of processes to five. The decision of limiting the business processes was also based on our experience from the pilot study (described below).
- A template for annotating business processes. It is a two dimensional table in which rows represent elements of the BPMM, and columns represent the processes to be annotated.
- A post task survey questionnaire to measure user perception of the model on a scale of 1 - 5 (Strongly Disagree, Disagree, Not Sure, Agree and Strongly Agree).

As part of the preparation of the experiment, a pilot study was conducted with three participants (PhD students). The purpose of the pilot study was to evaluate how well the participants were able to perform the experiment. The results and comments from this study were used to improve the BPMM elements definitions, business process descriptions and the template for the experiment.

### 3.3 Conducting the Experiment

For the experiment, 30 participants were given the materials (as described in section 3.2). This was followed by an explanation of the model, how to use the model and the template to annotate a process. Participants were then asked to annotate the business processes without any time constraint. After annotating the business processes, participants completed the post task survey. The response from 20 participants was received making the response rate 66.7%.

### 3.4 The Studied Variables

In order to evaluate the consistency and correctness of annotating business processes using BPMM, and the user perception of the model, the following three variables were defined:

**Variable 1. Annotation Consistency (AC):** It is the degree to which process annotation (using BPMM) by different people is identical. AC is measured by the number (in percentage) of participants with identical process annotation on individual elements of BPMM.

The steps taken for measuring AC are to let different participants annotate a set of business processes and then we compute AC as follows:

1. Let  $\text{Max}_{e,p}$  be the maximum number of participants with identical annotations on element  $e$  for process  $p$ .  $e$  is an element of  $\{\text{Resource, Actor, Process Level, Process Relationship, Process Area, Process Phase, Process Type}\}$ .

For example, suppose a process ( $p=1$ ) is annotated by 20 participants and for an element (*Process Level*), out of the 20 participants 12 annotate it as ‘operational’, 5 as ‘tactical’, and 3 as ‘strategic’. Therefore,  $\text{Max}_{\text{Processlevel},1}=12$ .

2. Annotation Consistency on element  $e$  for process  $p$ ,  $\text{AC}_{e,p} = (\text{Max}_{e,p} * 100)/N$ , where  $N$  is the total number of participants. For the example given above,  $\text{AC}_{\text{Processlevel},1} = (12 * 100)/20 = 60$ .

3. The average AC for an element  $e$ ,  $AC_e = (\sum AC_{e,p}) / n$  for  $p = 1 \dots n$ , where  $n$  is the number of annotated processes.

The existence of similarities in process annotation means that there is a common understanding of the BPMM between different people. This implies that the process metadata based on BPMM will communicate the same meaning to different people.

**Variable 2. Annotation Correctness (AR):** It is the degree to which process annotation (using BPMM) by different people is correct. AR is measured by the number (in percentage) of participants who correctly annotated a process for an element of BPMM.

The majority of participants may have a common but incorrect understanding of the BPMM model. Therefore, in order to determine whether the process annotation by participants is correct or not, the AR is measured.

For measuring the AR, the process annotation from different participants is compared with the process annotation from the inventors of BPMM, assuming that the inventors' annotation is correct. AR is computed as follows:

1. Let  $C_{e,p}$  be the number of participants with correct (identical to inventors') annotation on element  $e$  for process  $p$ . Where,  $e$  is an element in  $\{Resource, Actor, Process Level, Process Relationship, Process Area, Process Phase, Process Type\}$ .

For example, suppose a process ( $p=1$ ) is annotated by 20 participants and for an element (*Process Level*), out of 20 participants 12 annotate it as 'operational', 5 as 'tactical', and 3 as 'strategic'. Where, the correct (inventors') annotation is 'tactical'. Therefore,  $C_{Processlevel,1}=5$

2. The Annotation Correctness on element  $e$  for process  $p$   $AR_{e,p} = (C_{e,p} * 100)/N$ , where  $N$  is total the number of participants. For the example given above  $AR_{Processlevel,1} = (5 * 100)/20 = 25$ . Similarly, if the correct (inventors') annotation is 'operational' then  $AR_{Processlevel,1} = 60$ .
3. The average AR for an element  $e$ ,  $AR_e = (\sum AR_{e,p}) / n$  for  $p = 1 \dots n$ , where  $n$  is the number of annotated processes.

The existence of similarities in process annotation (between participants and inventors) means that the BPMM model elements are correctly understood. This implies that, the process metadata produced will be free of errors.

**Variable 3. Perceived Ease of Use (PEOU):** The degree to which a person believes that using the BPMM model for annotating processes would be free of effort. In order to investigate perceived ease of use we asked the participants to assess two statements on a scale of 1 to 5 (Strongly Disagree to Strongly Agree). The statements are, PEOU1 (The annotation definitions are clear and helpful for annotation), PEOU2 (It was easy to annotate the business processes).

### 3.5 Results and Discussion

In this section, the data collected from the experiment are analyzed and discussed in order to evaluate the BPMM elements definitions. For the analysis, the mean and the standard deviation of annotation consistency and correctness for each element are computed. Tables 1 and 2 and fig. 3 show the summary of statistics of process annotation.

**Table 1.** Annotation Consistency

	Resource	Actor	Process Level	Process Relationship	Process Area	Process Phase	Process Type
Mean	86.56	76.46	69.58	80.56	44.62	48.69	62.24
StDIV	12.40	12.24	21.19	9.62	3.23	14.16	14.60

**Annotation Consistency (AC).** The data in table 1 show that more than 62% of participants have identical process annotation for the following elements *Resource*, *Actor*, *Process Level*, *Process Relationship*, and *Process Type*. This indicates that there is a common understanding of these BPMM elements between different users. However, the *Process Area* and *Process Phase* elements have less than 50% of participants with identical process annotation. This indicates that the *Process Area* and *Process Phase* definitions are differently understood by the participants.

**Table 2.** Annotation Correctness

	Resource	Actor	Process Level	Process Relationship	Process Area	Process Phase	Process Type
Mean	86.56	76.46	69.58	80.56	36.84	42.64	54.66
StDIV	12.40	12.24	21.19	9.62	9.21	17.86	20.06

The data also show that the annotation consistency (similarity) of the same element varies between business processes. This is shown by high standard deviation i.e. 21.19 for the *Process Level* element.

**Annotation Correctness (AR).** The data in table 2 show that more than 54% of the participants have correctly annotated business processes for the elements *Resource*, *Actor*, *Process Level*, *Process Relationship*, and *Process Type*. This indicates that the BPMM elements definitions are well understood by different people, implying that most process metadata generated by users based on the model will be free of errors. However, less than 50% of participants have correct process annotation for the elements *Process Area* and *Process Phase*. The detailed analysis shows that participants who correctly annotated *Process Area* and *Process Phase* had more industrial experience compared to others. While the two elements are based on widely accepted frameworks [17, 21, 22], understanding and applying these definitions to annotate business processes seems to require some basic industrial experience, which many participants lacked.

Comparing the annotation consistency (AC) and correctness (AR), fig. 3 shows that AC is equal to AR for the elements *Resource*, *Actor*, *Process Level* and *Process Relationship*. This means that, for these elements, the majority of the participants who identically annotated the processes were correct. Therefore, the majority of the participants have a common and correct understanding of the BPMM and its element definitions. However, the definitions of *Process Areas*, *Process Phase* and *Process Type* were not correctly annotated so we hypothesize that these definitions need to be sharpened.

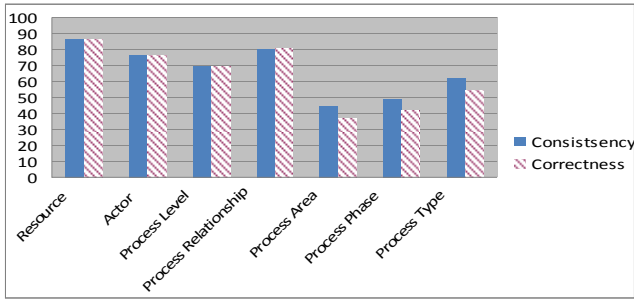


Fig. 3. Annotation Consistency and Correctness

**Perceived Ease of Use (PEOU).** Fig. 4 shows the summary of statistics for user perception of the model. More than 52% of the participants agree (agree and strongly agree) with PEOU1 (*The annotation definitions are clear and helpful for annotation*). Whereas more than 58% of the participants agree (agree and strongly agree) with PEOU2 (*It was easy to annotate the business processes*).

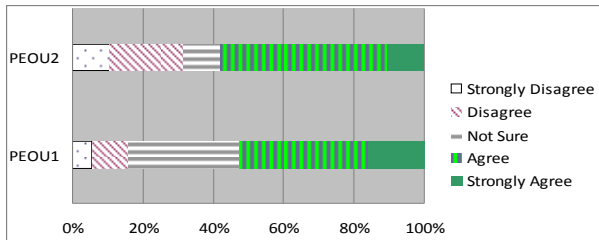


Fig. 4. Perceived Ease-of-Use

## 4 Conclusion

In this paper we have proposed a Business Process Metadata Model (BPMM) that can be used for annotating business processes to facilitate searching, interpreting process models as well as navigating the repository. BPMM is composed of elements derived from concepts which were elicited (from literature) and validated through an empirical study. While the complete validation of the model can only be achieved after implementation, the model is empirically evaluated through a controlled experiment to measure consistency and correctness of process annotation.

From the study, we have learned that the annotations of most of the BPMM elements by different people are identical and correct. This implies that the given definitions of BPMM elements are understandable. However, specifically the definitions for Process Area, Process Phase and Process Type need to be sharpened in order to increase annotation consistency and correctness.

One of the limitations of the study is that the annotation consistency and correctness for two elements (business goals and business context) is not measured. This is

due to the reason that there are no widely accepted values for the two elements. Future research aims at further validating the BPMM.

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