Appendix B. The paper-based documentation of the AmbiTRUS framework used in the experiment

RE-related problem	Criteria	Description	Violation	Example A, A': Potentially ambiguous user story / user stories B, B': Reformulated user story / user stories
Vagueness	*Lexical* Complete terminology	User stories should use the full name of a concept to avoid different interpretations	User stories use only a part of the full name of a concept	A: *"As a site administrator, I want to modify the profile*, so that only the name will appear"* (US1) B: *"As a site administrator, I want to modify the company profile*, so that only the name will appear"* (US1a) OR B: *"As a site administrator, I want to modify the user profile*, so that only the name will appear"* (US1b) *) The word "profile" in US1 is changed into "company profile" in US1a or "user profile" in US1b to allow for a correct interpretation of which profile is meant
	Precise terminology	User stories should use precise terminology to avoid different interpretations	User stories use imprecise terms that can trigger different interpretations of what is actually meant	A: *"As a site administrator, I want to manage* the company profile, so that only the name will appear"* (US2) B: *"As a site administrator, I want to modify* the company profile, so that only the name will appear"* (US1a) *) The word "manage" in US2 can be interpreted as many different actions, such as modify, create, select, filter, etc.
	Syntactic Atomic	User stories should not be written as a compound sentence	User stories are written as a compound sentence using a *coordinating conjunction* (e.g., and, or, but, for) that can cause multiple interpretations	A: *"As a site member, I want to scroll and* get a notification of upcoming courses, so that I can choose the most suitable course for me"* (US3)

RE-related problem	Criteria	Description	Violation	Example **A, A': Potentially ambiguous user story / user stories** **B, B': Reformulated user story / user stories**
				B: "As a site member, I want to scroll all upcoming courses, so that I can choose the most suitable course for me" (US3a) *OR* *B: "As a site member, I want to scroll courses, so that I can choose the most suitable course for me" (US3b)* *B': "As a site member, I want to get a notification of upcoming courses, so that I can choose the most suitable course for me" (US3c)* **) Compound sentence should be removed by splitting US3 into two user stories US3a and US3c (or US3b and US3c). Because of the "and" it is not clear whether "upcoming" holds only for the notifications or also for the scrolling.*
	Semantic Representative	User stories should express a clear intention of what the system should deliver.	User stories do not clearly express what the system should deliver.	*A: "As a manager, <u>I want to limit transaction processing*</u>, so that my employees are not pushed to the limit" (US4)* *B: "As a manager, <u>I want to limit transaction processing to the office hours*</u>, so that my employees are not pushed to the limit" (US4a)* **) "Transaction processing" in US4 has a vague meaning. Does it mean the amount of transactions that are processed or the hours during which transactions are processed?*
	Pragmatic Explicit statement	User stories should fully and clearly express something, leaving nothing implied	User stories contain implied meaning that is not directly stated in the sentence	*A: "As a customer, I want to <u>take money*</u>, so that I can pay my bill" (US5)*

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				B: "As a customer, I <u>want to withdraw money from my bank account</u>*, so that I can pay my bill (US5a) **) US5 is potentially ambiguous because "take money" can be interpreted in different ways (e.g., take cash out of my wallet, steal money from someone else) than the intended meaning if the context of the user stories is a bank (see also US4 and US4a).*
Inconsistency	*Lexical* Term consistency	User stories should use consistent concepts and terminology throughout a set of user stories	User stories use different concepts or terminology to express the same meaning throughout a set of user stories	*A: "<u>As a buyer</u>*, I want to take exams in the enrolled courses, so that I can evaluate my progress" (US6)* *B: "<u>As a site member</u>*, I want to take exams in the enrolled courses, so that I can evaluate my progress" (US6a)* **) The actor that is associated with US6 (and US3, US3a, US3b, US3c) is "site member", so, US6 should also use the term "site member" to represent the actor.*
	Syntactic No-overlapping	User stories should not contain *subordinating conjunction* that can trigger inconsistency to the delivered features in the system	User stories contain *subordinating conjunctions*, including when, until, because, while, if, although, after, as, before, whenever, since, and whereas	*A: "As a site member, I want to take exams <u>in the enrolled courses when I finish them</u>, so that I can evaluate my progress". (US7)* *B: "As a site member, I want to take exams <u>in the completed courses</u>, so that I can evaluate my progress". (US7a)* **) US7 is potentially ambiguous because the user story delivers inconsistent functionality with US6a which does not have the*

RE-related problem	Criteria	Description	Violation	Example A, A': Potentially ambiguous user story / user stories B, B': Reformulated user story / user stories
				condition "when I finished them". So, either US6a or US7a need to be removed, depending on whether exams can be taken only after courses have been completed.
	Semantic Conflict-free	User stories should not be contradictory to others	User stories contain conflict statements with other user stories	*A: "As a customer, I want to <u>pay online at any time</u>*, so that I can always immediately pay my bill" (US8)* **) US8 contradicts US4a. It is because "pay online" (US8) needs "transaction processing" (US4a) that will proceed only during office hours. So, it is not possible to pay the bill online "at any time". Probably US4a imposes a too strict requirement and should be discarded.*
	Pragmatic Combined understanding	User stories should be consistently validated with other user stories	User stories are inconsistently validated with other user stories	*A: "As a <u>site member</u>*, I want to modify the <u>company profile</u>*, so that only the name will appear" (US9)* *A': "As a <u>site administrator, I</u> want to modify the <u>company profile</u>*, so that only the name will appear" (US1a)* **) US9 and US1a are contradicting because, in US1a, the one who has access to modify the company profile is "a site administrator", while "a site member" can modify his/her own user profile (i.e., US1b). One of the two user stories needs to be deleted.*
Insufficiency	***Semantic*** Directive	User stories should express sufficiently that the system needs to do something.	User stories do not sufficiently express what the system needs to do.	*A: "As a customer, I want to <u>access my online bank account</u>*, so that I know whether I can pay my bill" (US10)*

RE-related problem	Criteria	Description	Violation	Example A, A': Potentially ambiguous user story / user stories B, B': Reformulated user story / user stories
				B: "As a customer, I want to <u>consult the balance of my online bank account</u>*, so that I know whether I can pay my bill" (US10a) **) The phrase "access my bank account" in US10 does not give clear information for the action that should be accomplished by accessing the bank account.*
	Pragmatic Contextual relevancy	User stories should be interpreted according to the context and system functionality	The formulation of user stories does not seem to be related to the context and intended system	*A: "As a customer, I want to <u>inquire about the balance of my account</u>*, so that I know whether I can pay my bill"* (US11) *B: "As a customer, I want to <u>consult the balance of my online bank account</u> *, so that I know whether I can pay my bill"* (US10a) **) US11 is not sufficient to transform into system functionality as this inquiry does not necessarily involved the use of a system by the customer.*
Duplication	**Lexical** No synonyms across user stories	User stories should avoid using different words, phrases, or terms having a similar meaning in a set of user stories	User stories contain words, phrases, or terms having a similar meaning in a set of requirements	*A: "As a site member, I want to <u>register</u>* in upcoming courses, so that I can follow the course"* (US12) *A': "As a site member, I want to <u>enroll</u>* in upcoming certification courses, so that I can follow the course"* (US12a) **) US12 potentially duplicates US12a, as "register" and "enroll" have the same meaning. One of the two should be deleted.*
	Semantic			

RE-related problem	Criteria	Description	Violation	Example **A, A': Potentially ambiguous user story / user stories** **B, B': Reformulated user story / user stories**
	Duplication-free (well modularized)	User stories should not describe functionality that is already included in another user story	The functionality expected from a system in a user story is already covered by another user story	*A: "As a customer, I want to <u>pay online during office hours</u>[*], so that I can pay my bill" (US13)* *^{*)} US13 requires functionality that is included in US8, so is not needed.*