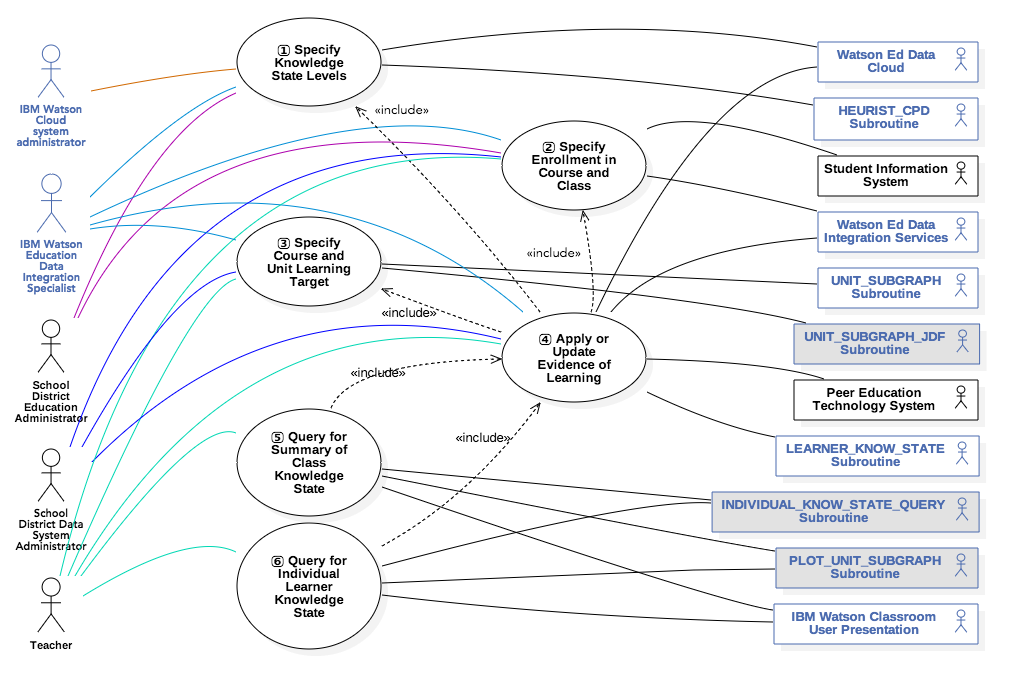
**Figure 1** — Use-case diagram for learning-map prototype.



| **Use Case Name**: ⓵ Specify knowledge-state levels | | | **ID**: Proto1 | **Importance Level**: |
| --- | --- | --- | --- | --- |
| **Primary Actors**:   * School-district education administrator (educational) * IBM-Watson Education Cloud system administrator | | Use Case Type: Overview, Essential | | |
| Stakeholders and Interests: | | | | |
| **External System Actors**: | | **Internal System Components**:   * Watson Education Data Cloud * HEURIST\_CPD Subroutine | | |
| **Brief Description**: Initially configure offering for school-district through specification of school-district policies for characterization of learner knowledge states. Also initialize a set of template Conditional Probability Distribution (CPD) tables from which a Bayesian-network learning-map is constructed. | | | | |
| **Trigger**: IBM-Watson Education Cloud system administrator initializes service for IBM Watson Classroom  Type: | | | | |
| **Essential Information Inputs**:   * KNOW\_STATE\_SPEC input table containing jurisdiction policy how implied knowledge state relates to observed evidence of learning for individual learners. | **Essential Information Outputs**:   * CPD\_LONG output table containing heuristically derived conditional probability distribution (CPD) table templates by which learning-map model is initialized. | | | |
| Relationships:  Association:  Include:  Extend:  Generalization: | | | | |
| **Normal Flow of Events**:   1. School-district administrator provides KNOW\_STATE\_SPEC table to IBM. 2. The IBM-Watson Education Cloud system administrator configures the system to support the new client. 3. The IBM-Watson data-integration team uploads the KNOW\_STATE\_SPEC into the data cloud for the new client. 4. The IBM-Watson Education Cloud system administrator initiates the HEURISTIC\_CPD subroutine, which creates a TENANT\_ID-indexed instance of CPD\_LONG table in the cloud. | | | | |
| SubFlows:  S-1:  S-2: | | | | |
| Alternate/Exceptional Flows: | | | | |

| **Use Case Name**: ⓶ Specify learner enrollment in course and class | | | **ID**: Proto2 | **Importance Level**: |
| --- | --- | --- | --- | --- |
| **Primary Actors**:   * School-district education administrator (registrar?) * School-distract data-system administrator * IBM-Watson Education Data-integration specialist * Teacher | | **Use Case Type**: Overview, Essential | | |
| Stakeholders and Interests: | | | | |
| **External System Actors**:   * STUDENT INFORMATION SYSTEM serves as system of record | | **Internal System Components**:   * Watson Ed Data Integration Services transform enrollment * Watson Education Data Cloud stores enrollment-data tables | | |
| **Brief Description**: Extract learner enrollment in courses from classes and upload into Watson Education Data Cloud. | | | | |
| **Trigger**: School-district registrar enrolls learner in course, class within school-district  Type: | | | | |
| **Essential Information Inputs**: | **Essential Information Outputs**:   * COURSE\_ENROLL table contains associations between learners, courses, classes, teachers. | | | |
| **Relationships**:  Association:  Include:  Extend:  Generalization: | | | | |
| **Normal Flow of Events**:   1. School-district education administrator (registrar?) enrolls learner(s) in courses, classes. 2. School-district data-system administrator extracts enrollment information from Student-Information System (SIS). 3. The IBM-Watson data-integration specialist verifies uploading of COURSE\_ENROLL table into Watson Education Data Cloud. 4. Teacher verifies course enrollment is accurately reflect in IBM Watson Education Classroom. | | | | |
| SubFlows:  S-1:  S-2: | | | | |
| Alternate/Exceptional Flows: | | | | |

| **Use Case Name**: ⓷ Specify Course and Unit Learning Objectives | | | **ID**: Proto3 | **Importance Level**: |
| --- | --- | --- | --- | --- |
| **Primary Actors**:   * Teacher * Teacher * School-District data-system administrator * IBM-Watson Education data-integration specialist | | **Use Case Type**: Overview, Essential | | |
| Stakeholders and Interests: | | | | |
| **External System Actors**: | | **Internal System Components**:   * Watson Education Data Cloud stores COURSE\_UNIT * Watson Ed Data Integration Services transforms the course unit learning-standards scope into COURSE\_UNIT table and uploads into IBM Watson data cloud. * UNIT\_SUBGRAPH subroutine constructs UNIT\_MAP\_EDGE\_LIST, comprised of all learning-map vertices within a specified radius of those pertaining to in-scope learning standards. * UNIT\_SUBGRAPH\_JDF (prototype only) calculates the joint-distribution function (JDF) for the learning-map model. | | |
| **Brief Description**: Construct Bayesian-network learning-map model for learning standards within neighborhood of in-scope learning standards. | | | | |
| **Trigger**: Teacher specifies learning-standards scope for current or soon-to-begin course unit.  Type: | | | | |
| **Essential Information Inputs**:   * COURSE\_UNIT table specifies “in-scope” learning standards for the current course unit. * CPD\_LONG (prototype only) contains the conditional probabilities for the learning map spanning the neighborhood of in-scope learning standards. * SIHLEARNING\_STANDARD\_PROGRESSION table lists all edges for all learning maps within scope of curriculum covered by IBM Watson Education classroom. | **Essential Information Outputs**:   * UNIT\_MAP\_EDGE\_LIST table contains learning-map graph edge lists for the learning map spanning the neighborhood of the in-scope learning standards. * GRAPHCLUST\_N\_UNIT\_MAP\_JDF (prototype only) contains the joint distribution function for all learning-map vertices spanning the learning-map neighborhood. | | | |
| **Relationships**:  Association:  Include:  Extend:  Generalization: | | | | |
| **Normal Flow of Events**:   1. Teacher specifies learning standards within scope of current instructional unit. In-scope standards are captured in a COURSE\_UNIT table. 2. School-district data-system administrator and IBM-Watson Education data-integration specialist upload COURSE\_UNIT table into Watson Education Data Cloud. 3. The IBM-Watson data-integration specialist verifies uploading of COURSE\_ENROLL table into Watson Education Data Cloud. 4. UNIT\_SUBGRAPH and UNIT\_SUBGRAPH\_JDF subroutines construct Bayesian-network model for in-scope learning standards and their neighbors. | | | | |
| SubFlows:  S-1:  S-2: | | | | |
| **Alternate Flows**:   1. Teacher specifies in-scope learning standards through feature in IBM Watson Education Classroom user interface. 2. The IBM-Watson data-integration specialist verifies uploading of COURSE\_ENROLL table into Watson Education Data Cloud. 3. UNIT\_SUBGRAPH and UNIT\_SUBGRAPH\_JDF subroutines construct Bayesian-network model for in-scope learning standards and their neighbors. | | | | |

| **Use Case Name**: ⓸ Apply or update evidence of learning | | | **ID**: Proto4 | **Importance Level**: |
| --- | --- | --- | --- | --- |
| **Primary Actors**:   * Teacher * School-District data-system administrator * IBM-Watson Education data-integration specialist | | **Use Case Type**: Overview, Essential | | |
| Stakeholders and Interests: | | | | |
| **External System Actors**:   * Peer Education Technology System (e.g., Learning-management system (LMS), assessments-data-management system) serves as system of record for evidence of learning. | | **Internal System Components**:   * Watson Education Data Cloud stores EoL\_MEAS table of measured evidence of learning for all enrolled learners and LEARNER\_KNOW\_STATE table of estimated learners’ knowledge state for all learning standards within span of learning map represented by UNIT\_MAP\_EDGE\_LIST. * Watson Ed Data Integration Services transforms the course unit learning-standards scope into EoL\_MEAS table and uploads into IBM Watson data cloud. * LEARNER\_KNOW\_STATE subroutine applies evidence of learning to Bayesian network and estimates knowledge state for unmeasured learning standards. | | |
| **Brief Description**: Apply evidence of learning to Bayesian-network learning-map model of learning-standards neighborhood of in-scope learning standards. | | | | |
| **Trigger**: Teacher records evidence of learning in Peer Education Technology System.  Type: | | | | |
| **Essential Information Inputs**:   * EoL\_MEAS contains evidence of learning for all enrolled learners. * UNIT\_MAP\_VERTICES and GRAPHCLUST\_N\_UNIT\_MAP\_JDF (prototype only) specify the Bayesian-network learning-map model. * COURSE\_ENROLL table contains learners’ associations with courses, classes, and their teachers. | **Essential Information Outputs**:   * LEARNER\_KNOW\_STATE table contains estimated learner knowledge states for all learners, learning standards within the span of the learning map specified by UNIT\_MAP\_VERTICES. | | | |
| **Relationships**:  Association:  Include:   * ⓵ Specify knowledge-state levels * ⓶ Specify learner enrollment in course and class * ⓷ Specify Course and Unit Learning Objectives   Extend:  Generalization: | | | | |
| **Normal Flow of Events**:   1. Teacher records evidence of learning in Peer Education Technology System. 2. School-district data-system administrator and IBM-Watson Education data-integration specialist upload EoL\_MEAS table into Watson Education Data Cloud. 3. LEARNER\_KNOW\_STATE subroutine captures all evidence of learning (EoL) for all learning standards in the learning map for learners enrolled in course, class. It applies those evidentiary profiles and states to the Bayesian-network learning-map model and produces LEARNER\_KNOW\_STATE table, containing probability that each learner’s knowledge state is in the knowledge-state levels categories specified in “⓵ Specify knowledge-state levels”. | | | | |
| SubFlows:  S-1:  S-2: | | | | |
| **Alternate Flows**:   1. Teacher records evidence via feature in user interface for IBM Watson Education classroom. 2. School-district data-system administrator and IBM-Watson Education data-integration specialist upload EoL\_MEAS table into Watson Education Data Cloud. 3. LEARNER\_KNOW\_STATE subroutine captures all evidence of learning (EoL) for all learning standards in the learning map for learners enrolled in course, class. It applies those evidentiary profiles and states to the Bayesian-network learning-map model and produces LEARNER\_KNOW\_STATE table, containing probability that each learner’s knowledge state is in the knowledge-state levels categories specified in “⓵ Specify knowledge-state levels”. | | | | |

| **Use Case Name**: ⓹ Query for Summary of Class Knowledge State  ⓺ Query for Summary of Class Knowledge State | | | **ID**: Proto5&6 | **Importance Level**: |
| --- | --- | --- | --- | --- |
| **Primary Actors**:   * Teacher | | **Use Case Type**: Overview, Essential | | |
| Stakeholders and Interests: | | | | |
| **External System Actors**: | | **Internal System Components**:   * Watson Education Data Cloud stores LEARNER\_KNOW\_STATE table of learners’ estimated knowledge state for all learning standards within learning map represented by UNIT\_MAP\_EDGE\_LIST. * IBM Watson Classroom User Presentation (or INVIDUAL\_KNOW\_STATE\_QUERY, PLOT\_UNIT\_SUBGRAPH subroutines in prototype only) queries LEARNER\_KNOW\_STATE and provides averages . | | |
| **Brief Description**: Apply evidence of learning to Bayesian-network learning-map model of learning-standards neighborhood of in-scope learning standards. | | | | |
| **Trigger**: Teacher records evidence of learning in Peer Education Technology System.  Type: | | | | |
| **Essential Information Inputs**:   * LEARNER\_KNOW\_STATE estimated knowledge state for all learners. * COURSE\_ENROLL table contains learners’ associations with courses, classes, and their teachers. Used to filter LEARNER\_KNOW\_STATE. | **Essential Information Outputs**:   * VERTEX\_STATE\_DIST contains the distribution class averages of knowledge-state probabilities for learning standards within span of learning map (see Figure 2 below). | | | |
| **Relationships**:  Association:   * Include: ⓸ Apply or update evidence of learning   Extend:  Generalization: | | | | |
| **Normal Flow of Events**:   1. Teacher views average knowledge state for all learners enrolled in class for an individual learning standard within scope or within a specified radius of within-scope standards and views representation of knowledge-state conditional probability distribution. | | | | |
| SubFlows:  S-1:  S-2: | | | | |
| **Alternate Flows**:   1. Teacher views average knowledge state for a specific, individual learner enrolled in class for an individual learning standard within scope or within a specified radius of within-scope standards and views representation of knowledge-state conditional probability distribution. | | | | |

**Figure 2** — Exemplary plot of a learner’s estimated knowledge states on a learning map.

