LEARNING PROGRESSIONS AND ONLINE FORMATIVE ASSESSMENT NATIONAL INITIATIVE

FINAL REPORT – ATTACHMENT 8

OPEN TECHNOLOGY FRAMEWORK REPORT

Contents

1 Executive summary

The Learning Progressions and Online Formative Assessment National Initiative (the initiative) is a nationally coordinated response to the *Review to Achieve Educational Excellence in Australian Schools.*

The *Growth to Achievement: On-demand resources for teachers* (expert panel paper) by Cawsey, Hattie and Masters identifies clear goals for the initiative to redesign contemporary teaching and learning.

While the vision of the expert panel paper looks at all areas of teaching, learning and assessment, the Open Technology Framework (OTF) is concerned with systems interactions and takes the following vision elements as its context.

- Educators across Australia have improved capacity to establish and understand where individual students or groups of students are located in their long-term progress in an area of learning.
- Educators are easily able to establish students' current levels of attainment, diagnose individual strengths, weaknesses and any gaps in learning so they can monitor learning progress over time.
- Educators will have new opportunities to engage in collaborative practice within and between schools and systems.
- Educators have access to on-demand resources with suggested links to worked examples and lesson plans outlining optimum next teaching and learning steps for each student.
- Educators have the flexibility to create their own assessment instruments by drawing on existing quality assessment tasks specific to what they are teaching and to individual students. This can be done in real time with immediate feedback to support minute-to-minute, week-to-week and month-to-month decision making.

The OTF is a portfolio of interoperability standards selected to ensure that all solutions identified for use, or created under the auspices of the initiative, can share information to create the most effective outcomes for formative assessment, in support of those vision elements. It also describes necessary supporting data infrastructure, such as machine readable learning progressions, and the processes involved in linking data together, required in order to deliver on that vision.

The OTF identifies the broad areas of activity that will require systems support, the flows of data between those systems that would benefit from interoperability support, and a set of standards and specifications with which to implement those information exchanges.

It is anticipated that the Learning Services Architecture will be updated to include support for the identified standards if the initiative moves forward to implementation.

2 Introduction

2.1 Background

The discovery phase of the initiative includes the development of an OTF to facilitate the exchange of data between the processes and systems used to support learning, assessment and the monitoring of student progress.

To develop the OTF a review of interoperability standards used in online learning and assessment was undertaken. Consultations were then held with representatives of: government school system authorities from all states and territories; representatives of the National Catholic Education Commission and a cross-section of commercial product suppliers involved in online assessment and learning management.

The consultations were undertaken to establish current technical capabilities available to support formative assessment and the role of interoperability standards as well as the challenges and opportunities that may arise in adopting a coordinated national approach. In addition, subject matter experts from the USA and Europe were also consulted. Full details are available in the *Open Technology Framework Consultation Report.*

This document provides a proposal for the OTF, based on desktop research and the findings from the consultations.

2.2 What is the Open Technology Framework?

The objective of the initiative is to ensure that teachers and students can realise the maximum educational benefit of effective progress measurement, and that systems can support them to achieve that objective in the least disruptive way possible.

To realise that benefit, the OTF identifies six areas of work that will need to be supported on an ongoing basis.

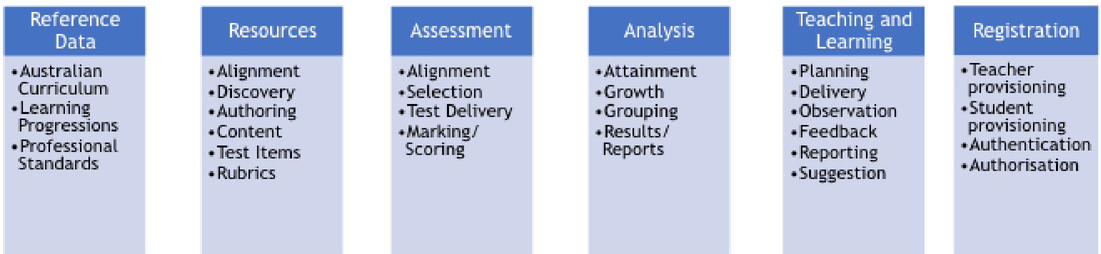

Figure 1: Six areas of work

The six work areas

Reference data

- The creation and maintenance of core shared information such as curricula, learning progressions, measurement scales, teaching standards etc.
- Typical supporting systems: repositories that provide digital versions of the reference data, authority websites

Resources

- The creation and discovery of assessment and teaching resources, and adding metadata and classification data to resources and resource collections (including alignment of learning progressions to resources), in order to enable discovery
- Typical supporting systems: resource repositories, item creation solutions, metadata management solutions

Assessment

- The activity of choosing assessments, delivering them to students, capturing responses and scoring and awarding results
- Typical supporting systems: tools that assist teachers to select assessments for individuals, item banks, suggestion engines, assessment delivery solutions
- Only the scoring of individual formative assessment pieces is considered here. Summative assessment, and end-of-semester grades of students, may be based on formative assessment scores. However, they constitute a distinct activity, which is out of scope of the formative assessment process described here.

Analysis

- The activity of helping teachers and students to make the best sense of results arising from assessments
- Typical supporting systems: tools that provide actionable feedback to students and teachers about their progress, suggestion engines to recommend next steps and resources, school or system-level analytics to help track cohort progress and teacher dashboards

Teaching and learning

- The ongoing daily activity of teaching in the classroom, capturing observations, planning and delivering lessons
- Typical supporting systems: student management systems (SMS/SIS/SAS), learning management systems (LMSs), planning tools

Registration

- The management of core student personal information, authentication and identity information that allows students to be enrolled in systems that provide assessments; the management of core staff personal information, authentication and identity information that allow teachers access to assessment, content and analytics services, and rostering of staff contact with students
- Typical supporting systems: student administration systems, enterprise identity systems

It is expected that different areas of work will run at different cadences; the creation of learning progressions and syllabuses, for instance, is an ongoing long-term activity that supports all other areas, whereas an activity such as resource creation can happen on an ongoing basis with much shorter timescales.

It is also clear that the work areas cannot function in isolation, but will need to share their outputs and process data from, and to, one another. That means that a defined set of data exchanges is necessary for formative assessment to occur: registration records are needed in assessment, resources are accessed in teaching and learning, assessment results are interpreted in analysis, and so forth.

The OTF is driven by the assumption that within each of these ongoing work domains, software systems will be in place that support the work and that capture and maintain the information and assets arising from that work – not as part of a single monolithic system, but as an ecosystem of entities, including school authority and vendor systems.

In order for every teacher and student to gain the benefits of shaping their learning around learning progressions, the systems that support each of those ongoing work areas will need to share their information effectively with one another.

The OTF looks at the key interactions between the ongoing work areas and proposes interoperability standards to be used whenever information is exchanged. It does not presuppose any particular architectures or design approaches in doing so: any system design decisions will be informed by investigations during the alpha phase of the project. (If any two areas of work do happen to be encompassed within the same system in a school authority, then no interoperability standard is needed for data exchange between them.)

There are five broad principles for the application of standards in the OTF.

- Standards are applied to business scenarios if they can help create a more empowering learning environment (an objective of the initiative).
- Standards are applied to business scenarios if they allow easy upgrade of solutions in a work domain to more effective solutions, or to prevent vendor lock-in.
- Standards are applied to business scenarios if they enable the initiative to integrate with existing solutions used by schools or school systems.
- Standards are selected due to their coverage in the market, so that users are not disadvantaged or burdened by having to implement unfamiliar protocols.

Project discovery work has identified several areas where data sharing between areas of work is hampered by lack of machine readable data and/or standards applied to that data. This collaborating work will occur within a set of ongoing business scenarios. To achieve the outcomes of the initiative the OTF is concerned with scenarios that will benefit from interoperability.

The five data exchange scenarios identified as requiring support through the OTF are:

- test provisioning: the creation of assessments that test progress effectively
- resource provisioning: creation, collation and distribution of resources to support assessment and teaching
- testing: all activities associated with providing accounts, access and assessments, as well as supporting teachers with suggestions for assessments
- assessment analysis: the interpretation of results from assessments with actionable suggestions to teachers as to next steps and suitable resources to maintain progress
- planning: building schedules of activity for classes and individuals, based on knowledge obtained from the ongoing formative cycle.

Planning relies on the exchange of other data within the school authority, including student wellbeing, timetables, attendance data and student collaboration. Supporting the exchange of that data is already a requirement for school authorities supporting planning, and is not considered further here. The OTF considers the interoperability consequences of exchanging only the data generated in the areas of work named above.

Note that none of these scenarios describe new work: these are all activities that already occur routinely in the classroom and the staffroom. The goal of the OTF, and a goal of the initiative in general, is to make these activities more efficient and less onerous for teachers, by making the data involved more readily available to systems, and automatic data exchanges, rather than requiring manual data entry.

3 Open Technology Framework Summary

Taking all five of the supported business scenarios above, and implementing the key information flows between work areas using clearly defined standards and information formats, gives us the following overall map of the necessary data exchanges:

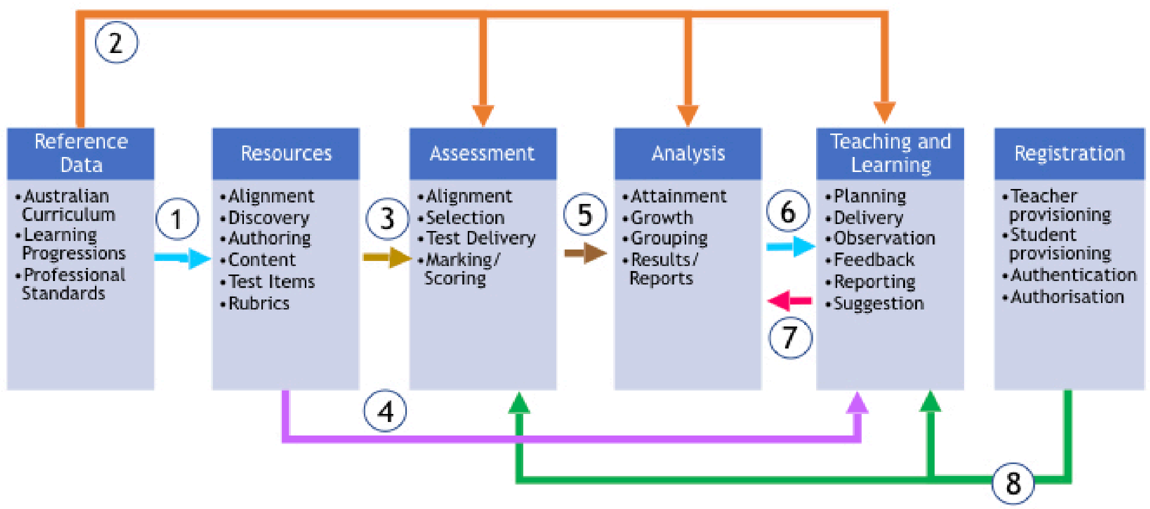

Figure 2: Online learning and assessment data flows

The table below summarises the nature of the data in each exchange and the viable standard(s) that can be used to implement that exchange.

Data exchange	**Anticipated data payload**	**Candidate standard/ Data model**
Curriculum and learning progressions data available for alignment of resources	Information from the curriculum and learning progressions that will be recorded as metadata in association with resources (assessment items, learning resources)	• (Linked data = URI) • Assessment: IMS QTI metadata • Learning resources: LRMI (IEEE LOM as legacy)
Curriculum and learning progressions available for assessment, analysis, teaching and learning	Curriculum and learning progression definitions, including links to related and including support information, in machine readable form	ASN RDF
Assessment resources available for assessment	Assessment item content to be played on an assessment platform	IMS QTI
Learning resources available for teaching and learning	Choice of learning resource to be delivered in learning	Local LMS integrations; IMS LTI
Results of assessment available for assessment analysis	Test item characteristics, rubrics, and scores for each item in a test, to be interpreted against learning progressions and curriculum statements assessed	SIF; IMS Rubric

Data exchange	Anticipated data payload	Candidate standard/ Data model
Reports of assessment analysis available for teaching and learning	Test results and suggestions for next learning steps	• Results: xAPI; SIF • Suggestions: Custom API
Observations from teaching and learning available for assessment analysis	Automated stream of learning event and teacher observation data, as tracking of student interactions with learning	• Event streams: xAPI • Teacher observations: Custom API
Registration of participants in assessment and teaching and learning	Minimal student records, to register student for assessment – containing roster of students associated with teacher, student identification, and minimal if any other personal data	Tiered approach: SIF; IMS OneRoster, IMS LTI Advantage, Google Classroom; IMS LTI, OAuth, SAML

Note that not all of the data exchanges have to be automated and interoperable in order for gains to arise – e.g. assessment delivery (3) can use existing software without moving to an interoperable standard, but the results of assessment can still be made available in an interoperable way for analysis (5).

Recommendations for next steps based on this summary are given in Section 3.1.

Full technical analyses of the selected standards are given in the appendices (Section 4 onwards). Established standards have been considered where they are relevant to the subject area and already represented in the Australian market, including SIF, the IMS suite of standards and xAPI.

3.1 Next steps

- Agree to use candidate standards going forward, where clearly defined and suitable, accepting that ongoing work will be required to close any identified gaps. The choice of standards for particular contexts, and the work required to support use of those standards in formative assessment, are given in the recommendations section of each appendix.
- Undertake pilot/research activities to establish the most effective approach, where there is no existing exemplar of good practice to draw on for information exchanges required within formative assessment. The areas of further investigation identified to date are listed below.
  - Alignment
    - Pilot an alignment capability against the National Literacy and Numeracy Learning Progressions, trialling various automated and semi-automated approaches for scalability. (This will enable both assessment item discovery, and learning resource suggestion.)
  - Reporting
    - No existing standard has been identified that captures the necessary richness required for formative assessment reporting. Standards development work should be undertaken to create such a standard.
    - Existing standards will need to be reviewed and enhanced for formative assessment results, particularly for rubrics.
    - Pilot closing the data transfer gap between formative assessment and teacher planning, moving from PDFs and data walls to feeding data directly into planning systems. This is the clearest current unserviced information exchange in the formative assessment workflow.

4 Appendix A: Metadata

4.1 Recommendations

- Use LRMI for learning resource metadata (newer and more adaptable than LOM).
- Use QTI LOM for assessment item metadata (bundled with QTI).

In addition:
- Maintain canonical mappings between LRMI and IEEE LOM to provide migration path for existing metadata in the IEEE LOM schema.
- Investigate loose coupling of learning progressions with metadata, via a more abstract layer.
- Expand the Vocabularies Australia vocabulary of accessibility types (http://vocabulary.curriculum.edu.au/access.html), to make it more applicable to assessment items, and aligned with the existing NAPLAN vocabulary.

4.2 Assumptions

- Providers of resources are prepared to expose and share metadata records along with resources, in an agreed format.
- There is a well-managed channel for providers to supply metadata records to systems. (This does not require the providers of resources to have full access to those systems).
- There is a sustainable critical mass of metadata records for resources coming from providers that meets the needs of an assessment system, or suggestion engine, respectively.
- Provider of resources has at least some capability to populate metadata records describing those resources.
- At least some metadata records will contain alignment to curriculum frameworks (including learning progressions) that are vouched for by experts.

4.3 Metadata schema selection

Metadata for education resources in general can be expressed in IEEE LOM, in XML, as profiled for Australian education in ANZ LOM; or it can be expressed in LRMI, in JSON.

LOM:
- IEEE LOM is quite old (2002), and while it has been hugely influential, it is not being actively maintained.
- IEEE LOM, and its Australian profile ANZ LOM, are bound to XML, which is increasingly a niche protocol; it is becoming harder to find developers familiar with it, or software language support for it.
- ANZ LOM is not straightforwardly extensible to include other information about resources. Its encoding of rights and licences, in particular, is awkward.
- ANZ LOM is very detailed and presupposes manual curation of metadata.

LRMI:
- LRMI is managed actively by the Dublin Core Metadata Initiative. It is based on schema.org, which in turn is supported by a consortium of search engines including Google and Yahoo.
- LRMI explicitly includes concepts from IEEE LOM, as an update of IEEE LOM for contemporary technologies. Mapping of IEEE LOM to LRMI is straightforward.
- LRMI is in JSON-LD, and very flexible and extensible. It is more amenable than LOM to incomplete, automated, and crowdsourced population of records.

- LRMI is compatible with semantic web approaches, such as are being pursued in NSW DET, and microformatting (embedding in HTML pages).
- NSW DET has migrated from ANZ LOM to LRMI for its resources, and has already profiled LRMI to use controlled vocabularies applicable to Australia.

IMS QTI:
- IMS QTI is the only widespread interoperability standard for assessment items.
- Assessment items have some metadata attributes specific to assessment, such as scoring mode and time dependence.
- IMS currently uses IEEE LOM for its resource metadata (IMS metadata); IMS QTI uses a profiled version of IMS metadata in QTI.
- Assessment systems can use a profiled LRMI alongside, or instead of, QTI LOM for a resource.
- IMS metadata has not been updated since 2006, and although IMS QTI and IMS metadata are in XML, IMS has used JSON-LD for all its new standards work for the last decade.

LRMI largely incorporates IEEE LOM, but is expressed in JSON rather than XML, and does not presuppose the level of manual curation that IEEE LOM does. NSW DET has already moved its metadata to LRMI, and LRMI is more sustainable going forward, and more flexible, than IEEE LOM.

For learning resources, we recommend using LRMI going forward for education metadata, with support for existing LOM metadata through mappings, instead of creating new LOM records. LOM is increasingly a legacy format and is awkward to extend which is likely to be needed for metadata to be put to varying uses.

Assessment resources in QTI are bundled with the QTI flavour of IEEE LOM, so by default QTI LOM will need to continue in use for assessment resources, especially if pre-existing QTI players are to be used. However, in the long term, a profiled LRMI (drawing from e.g. QTI LOM) would be more sustainable. Future QTI support for newer metadata schemas should be investigated with IMS.

4.4 Metadata schema for assessment Items

Assessment items used to assess competence against learning progressions need to be described with the following attributes. Mandatory attributes are asterisked. Attributes specific to assessment are daggered (and taken from QTI LOM).
- Identifier*
- Year level/Age range
- Key learning area*
- Version
- Date created
- Accessibility information (controlled vocabulary, will require updating from the instance in Vocabularies Australia)
- Time dependent (whether time to complete item impacts scoring)†
- Assessment interaction type (e.g. multiple choice, short answer – goes to distractor analysis)†
- Keyword
- Classification (possibly with controlled vocabulary)
- Rights/Licensing (preferably with controlled vocabulary; as QTI LOM specification notes, IEEE LOM rights encoding is unsophisticated)
- Relationship to other resources (note that QTI LOM includes relationships specific to assessment, including ‘precludes’†)
- Alignment: learning progression progress point*
- Alignment: curriculum statements covered
- Source of alignment information, for each alignment (for ranking): paradata, expert, recommendation, inferred
- Provenance of metadata

4.5 Metadata schema for learning resources

The metadata schema for learning resources used in formative assessment is broader than that used for assessment items, because of their broader usage. The following is drawn from ANZ LOM and the NSW DET profile of LRMI – fields that are incidental to likely learning resource use are omitted (e.g. resource authorship).

- Identifier*
- Year level/Age range*
- Key learning area*
- Version
- Date created
- Accessibility information (controlled vocabulary)
- Interactivity
- Classification, including learning approaches (Bloom's taxonomy etc), educational objective
- Keywords*
- Learning resource type
- End user role
- Rights/Licensing
- Relationship to other resources (including prerequisite resources)
- Size
- Format
- Duration (for media files)
- Time required to complete
- Alignment: learning progression progress point*
- Alignment: curriculum statements covered*
- Quality assurance/Provenance of resource
- Teaching and learning suggestions (LOM: education/description)
- Induced activity (MLR: 'expected learning behaviour when the learning resource is used')
- Source of alignment information, for each alignment (for ranking): paradata, expert, recommendation, inferred
- Paradata:
    - Popularity of object
    - Rankings given object by practitioners
    - Extent of use of object in context of given alignment
- Provenance of metadata

Paradata tracks the usage of the learning resource, which makes it important in the ranking of search results for resources against learning progressions. Paradata in the first instance is managed independently from metadata, since it is populated from different sources, and paradata is inherently dynamic whereas metadata is static. However, operational efficiency, including gathering all alignments in the one record, can lead to paradata snapshots being represented in metadata records. Note that the NSW profile of LRMI already includes the paradata fields Likes and Views, and alignment to the National Literacy and Numeracy Learning Progressions.

4.6 Representing alignment

By default, learning progressions and curriculum statements should be identified by the URIs used in the machine representation of those frameworks, rather than by local codes, to ensure that each statement is uniquely identified, and refers to a specific version of the framework.

As identified in the *Open Technology Framework Consultation Report*, maintenance of curriculum framework alignments to resources is an ongoing maintenance issue for both resources, and for consumers of curriculum frameworks.

- Explicitly aligning resources to specific curriculum statements (which will include learning progression progress points) means that the resource is authoritatively aligned for the current version of the framework – but that alignment will likely become invalid when the framework is updated.
- Maintaining the potentially many-to-many alignments of the old to the new version of the framework may address this issue, but it would be onerous to maintain, and the traversals from version to version would quickly become unmanageable.

A more abstract layer of representation of curriculum statements (including learning progressions) should be explored in this project, in particular for the alignment of resources. If effective, such a layer could eliminate the ongoing maintenance burden on metadata resources aligned to the National Literacy and Numeracy Learning Progressions.

5. Appendix B: Machine Readable Learning Progressions

5.1. Recommendations

- Represent learning progressions in a format consistent with that of the existing machine readable Australian Curriculum so that systems can easily consume both.
- Provide for versioning of the machine readable learning progressions and mapping to other curriculum frameworks.
- ACARA will explore how best to facilitate backwards mapping of changes between future machine readable versions as part of a proof of concept development for learning progressions.

5.2. Assumptions

- A mechanism exists for mapping between the old version and the new version of statements and progress points.
- Machine readable learning progressions are published and maintained online, as a component of the national education infrastructure.
- Not all information in a machine readable curriculum framework needs to be published by the same agency – e.g. while ACARA would be expected to publish the machine readable National Literacy and Numeracy Learning Progressions, any links mapping the National Literacy and Numeracy Learning Progressions to the NSW syllabus would likely be maintained by NESA instead.

5.2. Schema

The ASN RDF schema is flexible enough to deal with heterogeneous hierarchies of curriculum frameworks and the sparse population of attributes against different levels of the hierarchy. ASN RDF is available in JSON as well as XML, which ensures that it can be consumed in a relatively straightforward fashion by contemporary systems.

The hierarchical levels of each item in the learning progression would be as follows.

- General capability (e.g. Literacy, Numeracy)
- Element (e.g. Speaking and Listening, Reading and Viewing, Writing)
- Sub-element (e.g. Listening, Interacting, Speaking)
- Progression point (e.g. LIS1, LIS2, LIS3)
- Progression heading (e.g. under CrT8, ‘Informative’, ‘Persuasive’, ‘Imaginative’)
- Progression subheading (e.g. Comprehension, Vocabulary)
- Progression indicator (e.g. ‘distinguishes between sounds made with instruments’)

The attributes of each node are as follows.

- Identifier (URI)
- Code (currently only applicable to sub-element and progression point)
- Subject
- Title
- Description/Text
- Parent nodes (implicit in JSON presentation, explicit in RDF/XML)
- Child nodes
- Aligned nodes (in other frameworks)
- Aligned nodes (in older version of the same framework)
- Degree of alignment (superset, subset, partial overlap, identical)
- Keywords (uncontrolled)

- Terms (ScOT; requires controlled vocabulary and analysis)
- Optional: numerical value or range corresponding to progression point (depends on whether there is authoritative numerical scale provided by curriculum authority)
- Ordinal value (for sequencing)
- Education level

5.3. Versioning and mapping

Versioning and mapping should be incorporated into any machine readable curriculum framework, which is something that stakeholders have universally requested.

- Versioning consists of:
  - keeping online older versions of the framework
  - incorporating the version number into the unique identifier of each node in the framework
  - ensuring that the list of changes between versions can be recovered in machine readable form, and enumerates all nodes impacted.
- Mapping consists of:
  - identifying relevant nodes in other curriculum frameworks that correspond to the current node; for learning progressions; this includes older versions of the same learning progression, and the Australian Curriculum
  - identifying the degree of alignment for each pair of nodes, where feasible (superset, subset, partial overlap, identical)
  - providing a mapping between the two structures, to help downstream consumers working with both.
- As already discussed in Appendix A, loose coupling in aligning curriculum frameworks to resources (and other curriculum frameworks, including updates) should be investigated as an approach.

6. Appendix C: Assessment Items

6.1. Recommendations

- Use IMS QTI 2.2.
- Contribute to the development of IMS QTI 3.0, with a view to early adoption.
- If the range of item types in IMS QTI 2.2 is too restrictive for pedagogical purposes, there should be agreed use of complementary proprietary formats, in anticipation of a transition to IMS QTI 3.0.

6.2. Discussion

IMS QTI 2.2 is the closest there is to a cross-vendor standard for playing arbitrarily sourced test items in an assessment delivery system, and we recommend its adoption for assessment items, in order to make items available across a range of systems. However, QTI is only now starting to be broadly supported, and in fact the TAO player (https://www.taotesting.com) was until recently the only assessment delivery system broadly compliant with QTI.

QTI 3.0 is planned as a major revision of the standard to use HTML 5 natively. This will broaden the range of systems that can engage with it, and make it easier to implement and customise; but it may take years to mature and propagate through the market.

QTI interoperability is constrained by necessity to a small range of predefined item types, such as multiple choice and match. QTI can constrain the range of possible item types, and would reduce the opportunity for item designers to innovate and create more engaging content. It is expected that improved customisability in QTI 3.0 will address this concern.

7. Appendix D: Resource Suggestions

7.1. Recommendations

- Use custom API for request to suggestion engine. Investigate good practices in comparable systems in America or Europe.
- Allow IMS LTI to be used for any returned resources that require authentication.
- Establish national profile of IMS LTI, with reference implementation.

7.2. Calling suggestion engine

In order for the suggestion engine to provide resources appropriate for a student, it needs to know what stage the student has reached under an agreed learning progression. The sources of that information are teacher judgement and the formative assessment reports. That in turn presupposes that formative assessment reports are available in a standard machine readable form from which information can be passed on to a suggestion engine – an issue discussed further in Appendix F.

This information can be provided to a suggestion engine in a custom API, using the linked data URI identifiers for the relevant curriculum and learning progression points. Other relevant attributes of the student and their learning may also prove necessary. A distinct standard for information passed on to a suggestion engine is not needed; the API would use the same URIs to identify learning progression progress points as are used elsewhere.

7.3. Accessing suggested resources

The resources suggested as most suitable for the student need to be made available to the student. If an LMS is in place in the school the suggested resources will be made available to the student via the LMS; both students and teachers expect a level of interoperability between the LMS and any external resource, including single sign-on, and grade passback where applicable. Research undertaken for the *Open Technology Framework Consultation Report* identified that LMSs are in widespread use in both systemic and independent schools.

If the resources are freely available (e.g. online free resources), no further interoperability steps are required. If the resources are available to be ingested into the local LMS (the model followed by Scootle), the only interoperability requirement lies in how the resource is packaged for ingest (e.g. IMS content packaging, as used by the National Digital Learning Resources Network).

If, as is increasingly the case, the resource is externally hosted online and subject to authorisation, the resource will need to be made available to the LMS via single sign-on. IMS LTI is increasingly used to that end in Australian K–12 systems. However, implementations of IMS LTI by tool providers is notoriously inconsistent, and the sector would benefit from a national profile of IMS LTI, to make LTI integration less onerous for LMSs.

If there is no local LMS, LTI will not be applicable as a standard: schools will need to make their own arrangements for authentication with any external content provider, and there will be little prospect of single sign-on between the different content providers a school has access to. Any suggestion engine can mitigate this by returning metadata that clearly indicates whether a resource is subject to authentication or is freely accessible.

8. Appendix E: Assessment System Outputs

8.1. Recommendation

- Adapt complex SIF-US objects for adaptive test results (as already done for NAPLAN).
- Use SIF-AU objects for simple scores.
- Use IMS Rubric for rubrics, including alignment of rubrics to learning progressions.
- Use alignment to learning progressions in assessment item metadata, where present.
- Infer alignment to learning progressions using alignment capability, if alignment metadata is unavailable.

8.2. Breakdown

Any assessment analytics system needs to be provided with assessment system outputs, which it can align with learning progressions. The evaluation of progress against learning progressions, and suggestion of next steps, is an *output* of this process, and is discussed in Appendix F.

The following are possible ways for the assessment analytics system to align assessment system outputs with learning progressions.

- The assessment scores provided are broken down as subscores according to nominated learning progressions.
- The assessment scores provided are atomic, and aligned to learning progressions.
- The assessment scores provided are broken down as subscores according to a rubric, and the corresponding rubric is also supplied, and aligns the scoring points to nominated learning progressions.
- The assessment scores provided are atomic, and the corresponding assessment item is also provided, and aligned to nominated learning progressions.
- If the learning progressions used for any of these artefacts are not the same as the National Literacy and Numeracy Learning Progressions, the analytics system needs to be provided with either a mapping of the learning progressions used to the National Literacy and Numeracy Learning Progressions, or else a definition of the learning progressions used, which the analytics system can attempt its own mapping for.
- If no explicit alignment to any learning progression scale is provided in the assessment scores, assessment rubrics, or assessment item then the assessment analytics system may still attempt to establish alignment with the National Literacy and Numeracy Learning Progressions via an alignment capability. That would be the same alignment capability underlying the suggestion engine; any automated or semi-automated alignment would be based on the assessment item metadata and full text content if accessible.

In short, either the alignment to learning progressions is made explicit in the provided data, or the analytics engine has to infer the alignment.

8.3. Assumptions

- Assessment delivery system is prepared to share data with analytics system.
- Assessment delivery system can provide scores in format requested by analytics system.
- Assessment delivery system can provide details of assessment items that the scores correspond to.
- Assessment delivery system can provide rubrics in format requested by analytics system.
- Assessment delivery system can provide scores that are aligned to the given rubrics.
- Information about the alignment of scores, rubrics, or items to the National Literacy and Numeracy Learning Progressions is made available by the assessment delivery system to the analytics system, and that information is adequate to evaluate student progress against learning progressions. Where that is not the case, the analytics system can access a reliable alignment capability, which works out the alignment to the National Literacy and Numeracy Learning Progressions based on metadata and content analysis.

8.4. Assessment items

See Appendix A, 4.3 on the metadata recommended for assessment items; we recommend any available metadata about assessment items used in assessment should be made available to contextualise the scores received against them. Any alignment of a particular assessment item to learning progressions should either be explicit in the item metadata, or else recoverable via item metadata and item content. The test construct that the assessment item is located in may also be useful in establishing alignment, particularly if the test is adaptive.

8.5. Scores

Assessment scores can be represented in a range of standards, with different levels of complexity determined by the assessment instrument. The SIF-US set of StudentScoreSet, StudentResponseSet, AssessmentScoreTable are at the upper range of sophistication in representing student scores, including subscores, feedback to students, and score scaling. The SIF-AU representation of student results for NAPLAN is a drastically streamlined version of these objects. Even at that level of streamlining, however, they are more appropriate for complex adaptive tests, and some further modelling will be required.

The OTF recommends that, unless it proves unworkable in practice, a simple representation for assessment scores can be used for individual items and for short tests, grounded in markbooks and classroom assessment. The SIF-AU GradingAssignmentScore object is a good starting point; it models scores, with allowance for teacher judgements, and subscores. It does not explicitly assign subscores or scores to curriculum framework statements (although its companion object GradingAssignment does); but the subscore headings are open-ended, and could be repurposed to nominate learning progression level identifiers.

The object contains the following data fields.

- Student identifier*
- Class identifier
- Test item identifier*
- Date graded
- Iteration of attempt
- Mark/Score*
- Subscores (aligned to learning progressions)
- Teacher judgement

8.6. Rubrics

Scoring has been assumed to date to be an offline or in-house activity; for that reason there is a dearth of interoperability standards for rubrics. Even online rubric repositories like Rubistar in the US have ended up publishing rubrics as PDFs—although their rubric structure (a simple table) is clearly machine readable, and the site is set up to share rubrics online.

A critical requirement for formative assessment analytics is alignment of rubrics to learning progressions. The experimental SIF-US object Sif3AssessmentRubric is detailed (with extensive scoring definitions), but it does not provide any alignment to curriculum frameworks. The IMS Rubric specification, which is part of its E-Portfolio specification, is old and likely abandoned, but it does model ‘outcomes’, which can include curriculum framework statements. It is the best fit of the standards available to use as an input into analytics, because it is intended to showcase rubric application to an external audience, rather than be applied internally for marking.

While IMS Rubric can be used as the starting point of a machine readable rubrics specification, it will effectively be a new standard for rubrics, which have not had to be exchanged as inputs into analytics until now.

Schema of IMS Rubric:

- Identifier
- Title
- Description
- Outcomes
    - Can be learning progression levels, competencies more generally, or achievement levels
    - Include rules for judging when an outcome has been met, which can include scoring tables
- Dimensions of quality (breakdown of areas being assessed; cf. NAPLAN subscores in Writing)
    - Can include outcomes specific to each dimension

9. Appendix F: Assessment Results and Reports

9.1. Recommendations

- Start work on new standard for machine readable assessment reports.
- Pilot feeding machine readable assessment reports into planning process.

9.2. Significance

Assessment results and reports are how the abilities of a student evaluated against learning progressions are exposed to teachers and students. The transfer of assessment results and reports into planning is the critical step for linking assessment and learning in formative assessment. In terms of the capability model we have articulated, assessment reports provide:

- a consolidated view of student progress against learning progressions, across the entire cohort (or even for a single student)
- data about what learning progression stage a student has reached, which can inform a suggestion engine to propose resources appropriate to the individual
- data about what learning progression stage a student has reached, which can inform the next iteration of formative assessment for that individual.

However, planning to date has been envisioned as a manual process, applied to the entire cohort. Accordingly, assessment reports are provided as visualisations and PDF documents, and not in machine readable form. As our research has identified, there is little precedent or demand in Australia for exposing assessment results and reports at all in machine readable form, even as CSV.

Assessment results in machine readable form present a clear opportunity for improving data transfer efficiency, and reducing teacher workload, as an input into planning.

9.2. Need for new standard

As a result of the existing manual view of reports there is no overarching information model for assessment reports, and no applicable standard in place, especially where they include recommendations on teaching strategies. Any machine readable representation of assessment reports for the purposes of this project would build towards a new standard in the domain.

The systems that would make best use of a machine readable representation of assessment results would be LMSs, used to integrate planning for individuals and the cohort, searches for relevant resources through a suggestion engine, and single sign-on access by students to resources. However, the machine readable representation of assessment results will also likely be consumed by much more basic existing systems, including school-based analytics – which can be as simple as spreadsheets. So for any such information to be broadly usable, in the first iteration of implementation, it should be no more elaborate in format than well-defined CSV.

A simple data model would already be helpful in improving the workflow for planning across an entire cohort of students, and should form the basis of pilot investigation.

- Student identifier
- Assessment identifier
- Date
- Learning progression progress point
- Score received
- Identified learning progression indicators

10. Appendix G: Observations

10.1. Recommendations

- Use xAPI for any event streams that might contribute to analysing student progress.
- Capture teacher observations of learners against learning progression indicators, using custom API at this stage.

10.2. Discussion

Observation and measurement of data about student interaction with learning resources and LMSs, which can be fed to assessment analytics for a more global picture of student progress, are well suited to the event model of student interactions, captured by both the xAPI and IMS Caliper standards.

Of these standards, IMS Caliper is more tightly bound to conventional workflows of quizzes and completing modules, and has a well-defined and constrained data model. xAPI has a more open-ended and powerful data model, but for that reason has not prioritised interoperability, as different applications have each developed their own profiles of xAPI. Use of both in secondary education is only incipient, although there is interest in doing so in Australia, particularly in DET NSW and at the Connected Intelligence Centre, UTS, under Professor Simon Buckingham Shum.

Because it is more readily extensible, and because K–12 usage of learning analytics is still at an experimental stage, xAPI is recommended as the basis for any work on learning events. At this stage, any such work would be as a pilot.

Direct teacher observations about students can be added to xAPI as a model, but that would only be useful if xAPI is already in use in formative assessment, with a well-defined profile. At a preliminary stage, a custom API would be adequate, capturing the following data model.

- Student identifier
- Timestamp
- Course identifier
- Subject area
- Learning progression
- Learning progression indicators observed
- Free text observations

11. Appendix H: Student Registration

11.1. Recommendations

- Support both minimal information transfer for registration (single sign-on), and dynamic rostering of students into classes (though still with bare minimum of information required about student).
- Use SIF-AU where available.
- Use other widely used APIs and standards where available, including Google Classroom.

11.2. Assumptions

- The school maintains a roster of students enrolled in classes.
- All information required about a student by the suggestion engine (Appendix D) can be made available from the school, whether through a student management system, an LMS, or manual processes absent either.
- Schools are at disparate levels of technological maturity.
- The formative assessment system is resourced to support different applicable levels of maturity for student registration.
- The formative assessment system will benefit from richer levels of detail available through more mature technical approaches (such as dynamic updating of class cohorts).
- School authorities are concerned not to increase teacher workload, by minimising the need for teachers to manually intervene, to address issues in student registration.

11.3. Schema

Registration needs to convey the following information to any classroom assessment system.

- Student name
- Student identifier
- Accessibility requirements
- Teaching groups/Classes that the student belongs to
- Teacher responsible for the teaching group that the student belongs to
- School identifier

Registration also needs to provide the ability for students to access a remote classroom assessment system seamlessly, without needing to reauthenticate.

11.3. Interoperability standards

Of single sign-on protocols, OAuth 2.0 is the protocol in widest use, although some school authorities use the more secure and elaborate SAML protocol. Single sign-on can be used in conjunction with a full-fledged registration data flow, providing full student records; or it can register users by itself, on an ad hoc basis.

Ad hoc registration is much easier in both business and technology terms. The downside of ad hoc registration is there is no guarantee of rich data accompanying the student registration, or of identity management for the registered identity. Single sign-on protocols do provide a thin layer of registration data, which describes only the party registering (so not e.g. the teaching group as well); the popular IMS LTI standard is in effect a data wrapper around OAuth.

- Unlike other student registration processes like NAPLAN, registration information for formative assessment needs to be kept up to date against student movements between classes, which are ongoing during the semester.
- Unlike other classroom assessment systems, a classroom assessment system with broad scope (e.g. national scope, and not provided by a school system) will need to manage the identity of the student more effectively, and integrate it with any school-based identification of the student. If it is not, integration into the formative assessment loop will not be fully automated, as teachers will still need on occasion to work out which student corresponds to which marks.

The optimal setup for providing student identity to a formative assessment delivery system is a continuous feed of student records, in a well-defined format like SIF-AU or Google Classroom, tracking teaching groups as well as individual students, and with school authorities providing the same identifiers they use internally for tracking students. Because of the move to national consistency in at least the systemic sector, and Australian governance arrangements around it, we recommend SIF-AU as the preferred detailed registration standard.

Because of the disparity in maturity and standards adoption in Australian education, we suggest any assessment capability that has broader scope than a single school authority will need a tiered approach to registration, in order to allow access by any school in Australia.

- At the first tier, SIF-based continuously updated rosters and student records. All systemic authorities will be able to deliver this by the end of 2021.
- At the second tier, third-party integrators such as Wonde, delivering SIF-based integration on behalf of independent schools.
- At the third tier, other widely used standards for rostering, as continuous API-based feeds. IMS OneRoster, IMS LTI Advantage, and Google Classroom are able to deliver most if not all of the required level of information.
    - None of the protocols, including SIF, are currently able to deliver accessibility information, which would have to be provided out of band (although SIF-AU can be extended readily to provide that information in student records.)
    - Google Classroom does not provide for school identifiers, so differentiation between school instances would need to be managed out of band.
- At the fourth tier, other widely used standards for rostering, as CSV feeds, periodically updated. IMS OneRoster will support CSV feeds of cohorts, but that would require at least weekly, and preferably daily, updating of the CSV files to reflect current cohorts.
- At the fifth tier, single sign-on protocols used without a separate registration data flow.
    - The lack of information about teaching groups can be mitigated by including an identifier for the current teaching group as one of the attributes of the single sign-on login (e.g. as a custom claim about the student under OpenID Connect). However, that requires customisation of the school's OAuth service, which schools will usually not be equipped to do.
    - Without up-to-date information about the student's cohort, rosters will need to be updated out of band, by CSV upload or UI.

While the foregoing tiers reflect our understanding of the landscape, that understanding will need to be validated, and the relative market penetration of different standards will need to be established, in order to prioritise work.

12. Appendix H: Student Registration

- ASN RDF:
  - http://s3.amazonaws.com/jestaticd2l/purl/schema/standard
  - http://standards.asn.desire2learn.com/ASN_DF_Application_Profiles.html
- Google Classroom: https://developers.google.com/classroom
- IEEE LOM:
  - https://standards.ieee.org/standard/1484_12_1-2002.html,
  - https://en.wikipedia.org/wiki/Learning_object_metadata. Australian profile ANZ LOM:
  - https://www.ndlrn.edu.au/verve/_resources/ANZ_LOM_map.pdf
- IMS Caliper: http://specification.sifassociation.org/Implementation/NA/2.8/contents.xhtml
- IMS LTI Advantage: https://www.imsglobal.org/lti-advantage-overview
- IMS LTI: https://www.imsglobal.org/activity/learning-tools-interoperability
- IMS metadata: http://www.imsglobal.org/metadata/index.html
- IMS OneRoster: https://www.imsglobal.org/activity/onerosterlis
- IMS QTI 2.2: https://www.imsglobal.org/question/index.html
- IMS QTI 3.0: No public documentation released yet; see:
  - https://www.imsglobal.org/qti-versions
  - http://www.imsglobal.org/activity/qtiapip
- IMS Rubric: https://www.imsglobal.org/ep/epv1p0/imsrubric_specv1p0.html
- Linked data: See e.g.
  - http://linkeddata.org
  - https://www.w3.org/standards/semanticweb/data
  - https://en.wikipedia.org/wiki/Linked_data
- LRMI: https://www.dublincore.org/specifications/lrmi/
- OAuth: https://oauth.net
- SAML: https://www.oasis-open.org/committees/tc_home.php?wg_abbrev=security
- ScOT: http://scot.curriculum.edu.au
- SIF:
  - http://specification.sifassociation.org/Implementation/AU/3.4.5
  - https://www.a4l.org/page/Infrastructure3-3
- xAPI: https://xapi.com