A Conceptual Framework for Assessment of Learning in Technology Classroom Based Assessments

Donal Canty, Niall Seery, Jeffrey Buckley and Rónán Dunbar

The technology education curriculum in Ireland has gone through significant reform with the introduction of four new subject specifications at lower secondary school level. These new technology subjects were implemented in September 2019 and denotes a move from prescribed content and learning objectives syllabi to subject specifications presented in the form of learning outcomes. With the challenges of assessment practices in technology subjects well documented this curricular change has presented a unique opportunity to reflect on and consider how we capture and value features of technological capability. The pedagogical freedom afforded to teachers in interpreting the subject specifications is supported by the introduction of Classroom Based Assessments (CBAs), designed and implemented by the teacher. Therefore, the need emerges to explicate the features of quality necessary to mediate the teaching and learning agenda. This paper presents a framework, that is intended to guide teachers in formulating judgments in relation to levels of learner capability. As pupils learn and develop competency in the subject area, a shift occurs in terms of expectations of these capabilities. It is important that this progression is recognisable for both formative and summative assessment processes. Based on work in the area of reflective practice and learning, teachers' perspectives from practice and the goals for technology curricula, a typology is used to describe a shift from students being declarative, to being comparative, and finally to being able to demonstrate a capacity to critique. The nature of the assessment framework is such that it encourages the development of features of quality whilst simultaneously placing emphasis on learners' cognition. Descriptors and characteristics of these dimensions are presented in the paper.

Keywords: formative assessment, features of quality, capability, teacher judgment.

Introduction

There has been significant curricular reform of second level education in Ireland in recent years. The focus of the reform is at lower secondary level (The Junior Cycle) with particular emphasis placed on the development of *Key Skills* and the meaningful integration of formative assessment by teachers (Department of Education and Skills, 2015). The new Junior Cycle curriculum has moved from subject syllabi (traditional aims and objectives approach) to subject specifications (which include broader statements of learning), indicating a change from a behaviourist to a cognitivist epistemology. In practical terms, the emphasis has shifted from a content focus to a focus on the process of learning and the resultant outcomes from that. This gives flexibility to the teacher and learner in determining the most appropriate path to achieving curricular goals. The technology subjects in Ireland (of which there are four at Junior Cycle level; Engineering, Applied Technology, Graphics, and Wood Technology) are focused on the development of technological capability where the utility of knowledge, skills and values are explored and applied in the context of designerly activity. Each subject is situated in a discrete technological context that allows learners to choose an area of interest within the broad spectrum of technological activity.

The move to subject specifications is supported by a fundamental change of the assessment architecture for the new Junior Cycle curriculum by the introduction of classroom based assessments (CBAs). In addition to a design based project and terminal examination, within each subject students must engage with two CBAs during the three-year cycle. For the technology subjects, these are designed to support

the student and teacher in moving learning forward in the broad and dynamic contexts encapsulated by technology education. CBAs are intended to be formative in nature however they also have a summative role as they are also used to give a snapshot in time of the learners' capability that is assessed and recorded on the Junior Cycle Profile of Achievement award. This summative element is assessed by the class teacher and submitted to the State Examinations Commission (SEC) who are the national body responsible for curricular assessment. This is a historic move in the Irish education system as it is the first time that second level teachers have been charged with assessing their own pupils for a national award. The move to classroom based assessment requires a shift to teachers exercising their judgment on technological capability. With this focus, this paper aims to answer the following research question:

What is the theoretical framework that supports teachers in identifying features of quality as evidence of learning in student's work?

The presented framework aims to encourage and support the validity and reliability of teacher's holistic judgment on learner capability in classroom based assessments for the junior cycle technology subjects. The development of the framework was informed by current literature relating to assessment and learning in technology education, teacher experiences and observations and the curricular documents relating to the four technology subjects. The approach to this research captures the unique context of technology education in Ireland, the relationship between teaching, learning and assessment in technology education and outlines a framework that captures national policy intentions, perspectives on contemporary technology education and perspectives from practice.

Method

Due to the complex nature of teaching, learning and assessment in technology education a combined methodological approach to this work was utilised. The outcomes in this paper have resulted from a synthesis of contributions from three critical elements; research community, curricular documents and perspectives from practice. This combined approach was taken to ensure that contributions from relevant areas could highlight the complexity of the reality of implementing change in learning and assessment practices. As indicated by Moser (1996) the exploration of complex processes and interaction are often best investigated using informal "emic" methods. The informal methods are used as preliminary work to establish the variables that should be measured or observed in subsequent phases of research. To ensure reliability a substantial professional network of technology education stakeholders was consulted as part of this study.

The Nature of Technology Education: Implications for Assessment through CBAs

At the heart of the technology subjects in Ireland is a design-based philosophy typically enacted in alignment with constructionist theory (Harel & Papert, 1991). It is recognised that teaching and learning in design based activities is a complex and fluid process that potentially leads to divergent and creative outcomes (Buckley, Canty, & Seery, 2020; Seery, Buckley, Delahunty, & Canty, 2019; Seery, Canty, & Phelan, 2012). This can often be an uncomfortable bed fellow for assessment. For example, Stables (2020) discusses how the introduction of a simplistic linear model of the design process in the early stages of design education in the UK had a potentially negative impact on teachers' pedagogical practice and resultant experiences and outcomes for the learners. A critical point of note is the recognition of how this linear approach to teaching design was reinforced by assessment structures. If the assessment approach to designerly activity becomes overly specific and constrained, it can lead to the formulaic and routinised approach to assessment described by Kimbell et al. (2004). With this in mind, we must ensure that approaches to assessment, however well intentioned, take cognisance of the impact they may have on pedagogical practices and learner experiences. It is therefore imperative that guidance for teachers in relation to assessment focuses on interpretation of learners work as well as the mechanics of capturing evidence of the features of quality.

The challenge in the context of the CBA activity is in recognising the complexity of the learning through the CBA in a way that reflects how the learner thought and acted during the learning and assessment task. This also presents the challenge of giving the teachers and learners the tools and skills to communicate evidence of their learning and capability without reducing it to a procedural technique. A

challenge is therefore posed for any assessment instrument that endeavours to capture and quantify evidence of learning and capability as well as being an instrument for formative purposes.

The challenge of achieving constructive alignment within the context of a CBA

Achieving constructive alignment (Biggs, 1996) is central to efficacious pedagogical design. Employed pedagogies must be appropriately matched with meaningful objects of learning. Associated assessment architectures should ideally enhance the learning experience, but also must be valid, reliable and meaningful. The move to subject specifications sees a shift from a behaviourist to cognitivist epistemology when defining learning outcomes. Learning outcomes for Junior Cycle technology subjects no longer take the form of statements explicated by, for example, adopting specific verbiage from Blooms taxonomy (Dawson, 1998). Now, learning outcomes are denoted by broader "statements of learning" offering much more flexibility for teachers and learners in their approaches to achieving learning goals. Pedagogy in technology education, which usually evokes a constructionist narrative based on the predominance of design-based learning, but sees teachers at times adopting behaviourist, cognitivist or constructivist approaches where relevant, has in theory not been impacted by this change. Pedagogy in technology education, due to the emphasis on design, has always been associated with broader learning goals than those explicated in national policy documents. Now however, the challenge is on crafting an appropriate assessment architecture. A central feature of this approach is the introduction of classroom based assessments as a mandatory component of the Junior Cycle curriculum where features of quality are used to guide and evaluate pupil learning and progress. The features of quality are to be interpreted by the teacher and used to make an "on balance" judgment in relation to the level of student achievement in the CBA (NCCA, 2020). However, the limitation when relying on holistic judgement can circumvent the explication of what is of value, and as such could restrict the discourse essential in moving the student and their learning forward. Therefore, to maximise the utility of any assessment instrument/approach in context will require a frame of reference that supports both formative and summative assessment agendas. The problem is creating this in such a way that there is conceptual alignment with the intent of CBAs, the statements of learning, and associated pedagogies and that it facilitates a bridging of the theory-practice divide.

Perspectives from practice

Following the review of current literature, perspectives from stakeholders and practicing teachers were compiled and analysed to ensure that the proposed study takes cognisance of the challenges for practitioners in implementing the new form of assessment. The outcome from these perspectives was captured and collated to inform the development and implementation of assessment practice resulting from the curricular reform. Critical concerns from teacher discussions related to operationalising the CBA process and forming valid assessments of their students' work. This article therefore presents a heuristic framework for the interpretive specification of capability within technology education CBAs, which permits the quantification of judgements for formative and summative purposes. This involved generating "features of quality" inductively from the subject specifications and overlaying these with a typology of reflective practice (Jay & Johnson, 2002) as our assumption is that reflective practice is foundational to efficacious formative assessment. The elements presented hereafter are proposed as the central elements for further research where construct validity of the instruments and teacher judgment in determining quality of student work.

Features of Quality

The following features of quality and conceptual framework have been generated from a synthesis of the preliminary research work and an analysis and mapping of key skills, statements of learning and learning outcomes from the subject specifications. This resulted in the emergence of five features that were central to the nature and activity of a CBA. These features include research and analysis, knowledge and skills, communication, reflection and evaluation, and innovation. Importantly, each technology subject has a different context and approach to the development of technological capability and therefore it is expected that the nature and treatment of these features of quality will vary across subjects. Additionally, CBA 1 and CBA 2 have different emphases, with CBA 1 concentrating more on sourcing, validating and acquiring knowledge and skills, while CBA 2 shifts the focus further towards reflective practice. The articulation of the features of quality may not have the same emphasis across

subjects or across CBA 1 and CBA 2. This is at the discretion of the teacher, based on the needs of students, where the features of quality had to be determined to facilitate balancing the need to define focus without being prescriptive. It is critical that teachers are aware of this when making "on balance" professional judgements on their students' work for formative and reporting purposes. The five features of quality are broadly described below.

Research and Analysis

Research and analysis based activities are a large component of the CBAs and exists in multiple forms. In some CBAs, students must conduct research and analysis within the constraints of a particular context, in others the research and analysis are more constrained to a particular problem, and in others students must reflect on their prior work to consider how they will progress their own learning. In each case, research and analysis can be considered as a mechanism to use knowledge to solve problems or an activity to develop or acquire new knowledge. Therefore, through this activity, students should demonstrate innovation, or generate the knowledge necessary to innovate.

Knowledge and Skills

Knowledge and skills can be considered as both the foundation and goal for students engaging with CBAs. Students are expected to innovate in various ways that involves identifying problems, conducting research, and proposing or creating potential solutions. To do this, students need to have knowledge of the problem. That is, knowledge which is necessary to engage with the problem itself. Additionally, through these activities, students should acquire new knowledge that could be considered as knowledge for the solution (Barlex & Steeg, 2017). Students should be demonstrating both the knowledge they needed to begin a CBA, and the knowledge they acquired through their engagement with the process.

Communication

Communication in the technology subjects is unique from many other discipline areas, and this distinction comes from the knowledge base and its efficient and effective application in context. Demonstrating evidence of the previous features of quality (Knowledge and Skills and Research and Analysis) requires the student to be able to represent and present their knowledge, skills and thinking. Students must focus on what should be presented as well as how it is to be presented. Technical standards and conventions must be followed where appropriate to display knowledge of communication standards and techniques relative to the discipline. Students can explore and make decisions around representation formats such as orthographic views, isometric projections, perspective projections, graphs, tables etc. to demonstrate their competency of using these, and their knowledge of when to use these. Additionally, conceptual and ideation sketching is a critical feature of imaginative and innovative activity. With the "what" and "how" decided, students will also have choice in terms of the medium in which to communicate. A broad range of media should be considered and selected based on how effective it will be in communicating the students' work.

Reflection and Evaluation

Reflection within education should be a constant for students and teachers. The opportunities within technology subjects for students to reflect upon the abstractions of their thinking and be given the chance to materialise their resulting learning is an identifiable and unique contribution that technology education can make towards developing a learner's self-efficacies and metacognitive abilities. In CBA 1, students may be more focussed on acquiring knowledge through research, investigation and action, but reflection is necessary for students to consider their current levels of knowledge for the problem or task and what they gained from the activity. In a CBA 2, the need for reflection is made more explicit as students are asked to reflect on their prior work, or to research on an area in preparation for a final project. In all cases students should reflect and evaluate where they currently are in their learning which will help situate themselves for the task at hand and to understand what they need to gain from a CBA to progress their own learning so they can adequately engage in future activities.

Innovation

Technology education places significant emphasis on innovation. While this can be defined in many ways, it is typically differentiated from creativity by added implementation and domain specific

components. In this way, technology students must go beyond generating ideas by putting them into practice. Students can be innovative in multiple ways from proposing solutions to global problems to being innovative in their presentation of coursework. All of the previous features of quality listed are significant aspects of being innovative, as knowledge is used in identifying, for example, when, where, and how to innovate, while research can be conducted in innovative ways and is often needed to determine the value of innovative activity.

Conceptually Framing Progression

In order to aid teachers in providing formative feedback to students based on their work in the CBAs with reference to the features of quality, it is necessary that clear and coherent standards and levels of attainment exist to support them in making professional judgements. Within the technology subjects the CBAs are progressive in their aims. CBA 1 aims to emphasise discipline knowledge and/or skill acquisition, while CBA 2 shifts the emphasis towards reflective and evaluative practice. As such, the features of quality that are associated with CBA 1 are the same as those associated with CBA 2, however they will typically be emphasised or treated differently. While the weighting of certain features of quality may shift from CBA 1 to CBA 2, as they are progressive, each feature can be considered as being on a continuum. This is a useful approach as it increases the opportunity for students to receive progressive formative feedback due to the consistency in features of qualities across CBA 1 and CBA 2. These also align with the skills and attributes that students will need to complete their project activity that forms a significant part of the subject assessment for each of the technology subjects.

Standards

To operationalise the proposed framework, it is important to define the two continuums that are used to provide formative feedback and judge the quality of students work through the CBAs. The first is provided within the subject specifications (Department of Education and Skills (2018a, 2018b, 2018c, 2018d) as expectations for students in terms of standards. These include “exceptional”, “above expectations”, “in line with expectations”, and “yet to meet expectation”.

The second continuum, which we have developed to aid teachers in operationalising their professional judgement, provides guidance for differentiating work across these four levels. As students learn and develop competency in a subject area, a shift occurs in terms of expectations. Therefore, what was once considered to be above expectations may now be considered to be in line with expectations. Adopting a typology of reflective practice (Jay & Johnson, 2002) as we recognise that the governing formative aim of a CBA is for students and teachers to reflect on current levels of capability, and re-contextualising the three dimensions, we propose the following as dimensions for formative and summative CBA assessment:

Descriptive: Emphasis on Actions

Work at this level is generally prescriptive in nature. There is relatively little depth in terms of the thinking that students would exhibit at this stage, and the work is considered largely at an individual or personal level. There is an emphasis placed on students gaining competency, and in being accurate and precise in their work. This level is where the student presents the knowledge and skills that they feel is relevant to the task or activity. The student, based on the nature and context of the activity, must construct this. The issues that they determine central to the task will influence future work but at this level the student has yet to resolve this.

Comparative: Emphasis on Assumptions

Work at this level sees students beginning to consider what they are doing from multiple perspectives. At this level, students must show that they are open to the discovery of new things or phenomena. At times this may be at odds with the task or problem at hand or the student’s own beliefs or values. Demonstrating a capacity to try and understand and resolve alternatives or different interpretations of the same thing are key features of operating at this level. Students will identify, combine and analyse critical issues relevant to their work, drawing inferences that will shape their future actions or proposals. Examples could be students comparing potential approaches to presenting information, solving problems or considering the impacts of their decisions on others.

Critical: Emphasis on Context

Work at this level sees students critically considering what they are doing and presenting, evidenced from ethical, moral, or democratic dimensions where appropriate, and reflecting on how and why they are making decisions. This level reveals the decision-making process of the student where they are critiquing their own ways of thinking and working, and other sources of information. Through the descriptive and comparative levels students will have identified issues and made proposals on how they will act or proceed. Now their task is to choose a path that they feel will lead to successful outcomes. At this level the students are demonstrating a range of qualities that progress their ideas forward by bringing together their thinking, understanding and actions in relation to the task.

Synthesising these two continuums (i.e. the levels of attainment which range from "yet to meet expectations" to "exceptional", and the typology of "descriptive", "comparative" and "critical" evidence of learning), allows for the creation of a developmental conceptual framework to support the formative and summative assessment of CBA tasks with reference to features of quality (Figure 1).

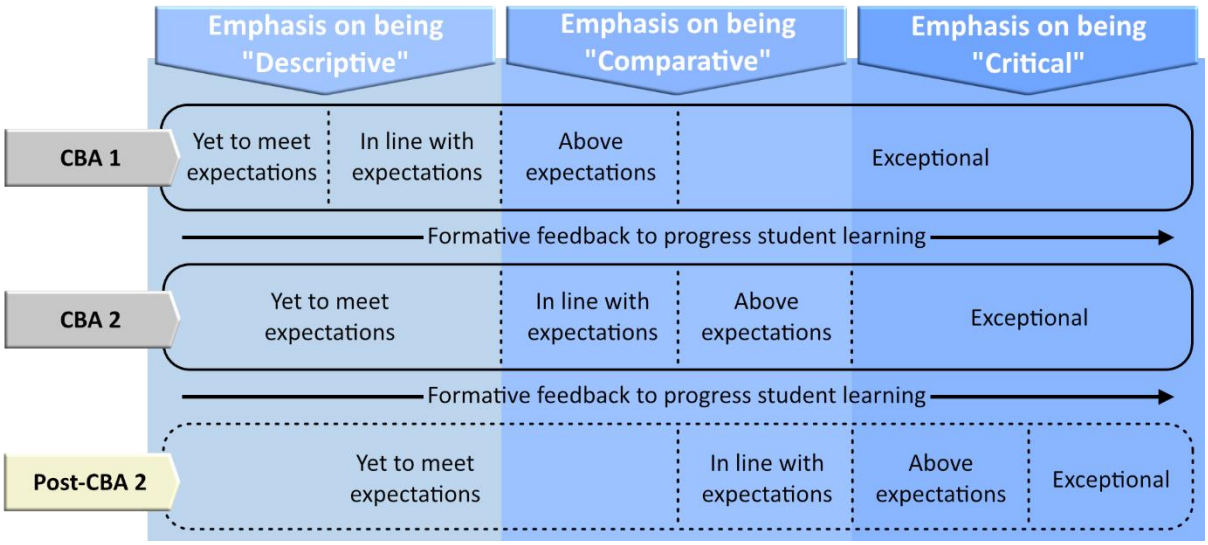

Figure 1. Conceptual framework for CBA assessment.

The conceptual framework for progression illustrates a staggering of the levels of attainment, providing an intuitive appreciation for how student learning and associated expectations develop over time. For example, work that would be deemed "above expectations" for a student in a CBA 1, becomes "in line with expectations" in CBA 2. Importantly, this framework does not limit students in that all students at all times can demonstrate exceptional work, or work that is yet to meet expectations. However, the likelihood of this should vary over time in line with their development and as a function of the CBA that is designed by the teacher. The concept of "post-CBA 2" is positioned to describe a period of time shortly after CBA 2, where over time demonstrating a capacity to critique will become the expected standard for students during their lower secondary education experience.

Conclusion

Students in the field of technology can be excellent in dramatically different ways (Kimbell, 2007). It is this principle that has supported the development of broad features of quality that frame the requirement of an enquiring disposition that simultaneously define critical foundational focuses and a direction of travel. The acknowledgment of post CBA activity is critical in understanding the role of CBA 1 and 2 in the holistic development of the student. Additionally, the overlapping conception of CBAs in the technology subjects reinforces the foundational knowledge and skills requirement that underpins subsequent innovative activity. Acknowledging the impact that assessment can have on pedagogy and learning, it is imperative that the new approach to Junior Cycle assessment is carefully considered so

that any impact that it may have will be a positive one. The presented framework in this paper was constructed as a result of an analysis and mapping of the newly defined technology subject specifications onto the goals of developing technological capability. Consultation with key stakeholders, and an alignment with previous research were also integrated into the definition of the framework. The resulting theoretical framework offers teachers a model developed around the principal features of quality and associated standards of technology education, on which they can base their evaluation of their students' work. Future work in relation to this study will involve trialling and testing the framework for validity and reliability as the new curriculum is rolled out. This will be conducted with attention being paid to both formative and summative assessment and will be evaluated in terms of its functionality in helping teachers discriminate on the levels of attainment of their students in the CBA activities.

References

Barlex, D and Steeg, T (2017). Re-building Design & Technology In the secondary school curriculum version 2: A working paper. United Kingdom: D&TforD&T.

Biggs, J. (1996). Enhancing Teaching through Constructive Alignment. *Higher Education*, *32*(3), 347–364.

Buckley, J., Canty, D., & Seery, N. (2020). An exploration into the criteria used in assessing design activities with adaptive comparative judgment in technology education. *Irish Educational Studies*, *0*(0), 1–19. https://doi.org/10.1080/03323315.2020.1814838

Dawson, W. R. (1998). *Extensions to Bloom's Taxonomy of Educational Objectives*. Sydney: Putney Publishing.

Department of Education and Skills (2015). Framework for Junior Cycle. NCCA.

Department of Education and Skills (2018a). Junior Cycle Applied Technology. NCCA.

Department of Education and Skills (2018b). Junior Cycle Engineering. NCCA.

Department of Education and Skills (2018c). Junior Cycle Graphics. NCCA.

Department of Education and Skills (2018d). Junior Cycle Wood Technology. NCCA.

Department of Education and Skills (2020). Junior Cycle Applied Technology: Guidelines of Classroom-Based Assessments. NCCA.

Harel, I., & Papert, S. (Eds.). (1991). *Constructionism* (pp. xi, 518). Westport, CT, US: Ablex Publishing.

Jay, J.K. & Johnson, K.L. (2002). Capturing complexity: a typology of reflective practice for teacher education. *Teaching and Teacher Education*, 18, 73-85.

Kimbell, R. (2007). "E-assessment in Project e-scape." *Design and Technology Education: An International Journal* 12(2).

Kimbell, R., Stables, K., Wheeler, T., Miller, S., Bain, J. and Wright, R. (2004). Assessing Design Innovation. London, *Department of Education and Skills*.

Moser, M. Gatehouseand H. Garcia, H. (1996). Urban Management and Poverty Reduction Urban Poverty Research Sourcebook Module II: Indicators of Urban Poverty. UNDP/UNCHS (Habitat)/World Bank

Seery, N., Buckley, J., Delahunty, T., & Canty, D. (2019). Integrating learners into the assessment process using adaptive comparative judgement with an ipsative approach to identifying competence based gains relative to student ability levels. *International Journal of Technology and Design Education*, *29*(4), 701–715. https://doi.org/10.1007/s10798-018-9468-x

Seery, N., Canty, D., & Phelan, P. (2012). The validity and value of peer assessment using adaptive comparative judgement in design driven practical education. *International Journal of Technology and Design Education*, *22*(2), 205–226. https://doi.org/10.1007/s10798-011-9194-0

Stables, K. (2020) Signature Pedagogies for Designing: A Speculative Framework for Supporting Learning and Teaching in Design and Technology Education. *Pedagogy for Technology Education in Secondary Schools: Research Informed Perspectives for Classroom Teacher,* 99-120. Springer International Publishing.

Dr *Donal Canty* is a Lecturer in Initial Teacher Education at the University of Limerick. He is qualified as a Post-Primary Teacher in the technology education domain. His research interests are in the areas of pedagogy and assessment. His doctoral studies investigated the impact of Adaptive Comparative Judgment (ACJ) on student learning in Initial Teacher Education. Donal is one of the founding members of the Technology Education Research Group (TERG).

Dr *Niall Seery* is currently Deputy President of Athlone Institute of Technology, Ireland. He served as Vice President of Academic Affairs and Registrar before taking the role as Director of the Technological

University Project at AIT. He has a PhD in Engineering Education and in 2010 he founded and continues to direct the Technology Education Research Group (TERG), where he is still active in research development and mentorship.

Dr *Jeffrey Buckley* is a researcher in technology education with specific interest in how people learn, and research methods and practices. He is a Lecturer at Athlone Institute of Technology, Ireland, and an Affiliate Faculty Member of the Department of Learning at KTH, Royal Institute of Technology, Sweden. He is a member of the Technology Education Research Group (TERG) and the Learning in Engineering Education and Progress (LEEaP) research group.

Dr *Rónán Dunbar* is a lecturer on Mechanical Engineering Programs at Athlone Institute of Technology in the areas of Manufacturing Systems, Project Supervision, Machine Control, Engineering Drawing and CAD. He is the coordinator of the B.Sc. in Polymer Processing Technology and the M.Sc. in Engineering Education offered within the department of Mechanical, Polymer and Design. He currently supervises 5 postgraduate research students in the area of Engineering and Technology Education.