Effective support for reflective writing in mathematics

eSTEeM Final Report

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The Open University

Contents

Executive summary

This report focusses on an in-depth study of 12 students identified as ‘improvers’ in Mathematics Education modules. Thematic analysis of interview data indicated the nature of difficulties in the ways of working and writing required for mathematics education assignments, and the approaches that students considered beneficial in their improvement.

The findings from the project have already been incorporated into the production for two new modules. They resulted in the adoption of an integrated approach to assessment, with changes in: assignment design; teaching about writing and modelling ways of thinking. Although not attributable to one cause, successful student outcomes show the potential of making use of student knowledge in module design. The lessons are now informing work towards embedding employability skills of communication and reflection into other Maths & Stats module assignments.

Report

Aims and scope of your project

The project aimed to:

- inform the mathematics education community about ways to support distance-learning students with reflective writing in mathematics.
- diversify the range of resources offered in module and teaching materials.

Its objectives were to:

- investigate difficulties experienced and approaches used by Open University (OU) mathematics education (ME) students who have improved their reflective writing over the course of a module.
- identify, through attention to minority voices, how assessment practices and resources could be more inclusive.
- identify effective ways of supporting students *through* written feedback and guidance.
- identify any potential for supporting students through resources *other* than written feedback and guidance.

Activities

The project was planned in five phases to ensure it aligned with the production schedule for two new modules, ME321 *Learning and Doing Geometry* and ME322 *Learning and Doing Algebra,* and the project team were a subset of those production teams. Starting with the principle of 'learning from improvers', Phase 1, in early 2021, involved analysing student performance data to identify an appropriate group of student participants from the predecessor mathematics education modules. Phase 2 (March - May 2021) involved recruiting and interviewing four participants who had already completed mathematics education modules. This led to Phase 3: preliminary data analysis and

dissemination that informed the final writing of module ME321 during summer 2021. Phase 4 (June – July 2021) involved recruiting and interviewing seven participants from the just-finished 20J cohort. Finally, the longer Phase 5 involved analysis of all data, input to the design of module ME322 during production (January 2022 – March 2023) and writing the final report. The rest of this section provides details of the main data collection and analysis activities and the rationale for their design.

Mobilising student knowledge

This project built on ideas from the eSTEeM project *Succeeding Against the Odds* (Calvert, 2017) which interviewed Level 1 students who had proved successful despite being identified as at risk of failure, and which led to providing introductory module activities that were of benefit to all students. Mathematics education (ME) modules are Level 3 (final year) undergraduate modules, but the majority of students are new to the skills of analytic and reflective writing since their earlier modules (on the core *Mathematics and its Learning* qualification) involve writing mainly symbolic mathematics. Other students join the Level 3 ME modules with experiences in writing for science or education modules but, surprisingly, analytic data had suggested that pass rates were not obviously affected by qualification. We reasoned that writing for ME modules has specific inter-disciplinary elements which require in-module learning, and that strengthening our support for that introductory process was more beneficial than attempting to define entry pre-requisites. The most relevant experiences to understand were not those of the most successful students, but those who had improved during a ME module.

In addition, the ME team had identified demographic performance gaps in recent presentations, specifically for Black students (2% of 20D/20J cohort), Asian students (12%), students with less than 2 A-levels (18%), and students with low SES (11%). While all OU students are non-traditional in their choice of university, these are students from backgrounds historically excluded from Higher Education. There is considerable literature on academic literacies (although not usually in mathematics) which not only critiques universities'

expertise in teaching academic writing to novices but also whether the socio-cultural norms underpinning it are outdated and exclusionary (e.g. Butcher et al., 2017; Lillis & Turner, 2001). We decided, where possible, to interview students from these under-represented groups to understand how they position themselves in what we see as the important educational space between learning and learning to be assessed, similar to what Ross (2011) calls "high-stakes reflection". We note also Odeniyi's (2016) ethnographic study of undergraduates with African diasporic connections which highlighted that reflective writing is a hybrid autobiographic/academic text produced in a space where some people's experiences and voices are othered by institutional practices. She found that these students mobilised peer support to understand the teaching and feedback provided by university, suggesting students themselves have knowledge that could improve inclusivity and attainment. Our research design opened a space to mobilise similar student knowledge about ME writing.

Identifying a participant group

We established the criteria for identifying what we meant by 'improvers', using past module performance data to check that an appropriately large sample would be produced (bearing in mind that Calvert (2017) had a 6% response rate). The *overall improvement* criterion was that students' assignment scores in the second half of the module were, on average higher than those in the first half. The *trajectory* criterion was that scores improved between consecutive assignments (with one drop ignored). The *final improvement* criterion was that end-of-module assignment (EMA) scores were either 10+ marks higher than their first mark *or* better than two previous assignments.

After obtaining HREC ethical clearance, we used the Student Survey Panel (SRPP) process to obtain demographic and performance data for the 314 students from four ME module 2020/21 presentations. Applying all three criteria resulted in identifying 104 improvers, of whom we had permission to contact 64. We prioritised 23 students who had identified they were in at least one of the priority groups (i.e. with Black or Asian ethnicity and/or low socioeconomic status

and/or qualifications equivalent to less than two A levels) and a further 24 with the strongest improvements, and then made contact via module tutors to improve uptake. 17 students indicated initial willingness, resulting in 12 agreed interviews, so no further contacts were made. Only three interviewees came from priority groups so our aim to over-recruit was not fully achieved.

Interviews

Four interviews were conducted in Phase 2 and eight in Phase 4, carried out by two experienced Associate Lecturers recruited into the project. Interviews were semi-structured, synchronous, online via Teams or Skype, recorded and then professionally transcribed. This choice, rather than, say, asynchronous email interviews, arose because we consider interview texts to be accounts of experience which draw on an assumed local discourse (Ramazanoglu & Holland, 2002) . Educational settings are recognised as key spaces in which one learns how to account for one's own progress for oneself and others (James, 2007; Rose, 1998), but we reasoned that a distance-learning setting may not provide the same shared language and understandings and that the possibility of asking for clarification was important for both the interviewer and interviewee. Indeed, Odeniyi's research cited above shows that these understandings are not necessarily shared in face-to-face universities. Thus the interview would be "itself a site for knowledge production" (Borer & Fontana, 2012, p. 50) in which both interviewer and interviewee are active in drawing on local and institutional discourses to co-construct new meanings about learning to write.

The interview schedule (see Appendix B) was constructed with the interviewers and only minor changes to wording were made between the two phases. Interviewees had been told that they had been chosen as 'improvers' and that the results of the research would contribute to creating new modules.

Sections 1 and 2 of the schedule focused on the interviewee as a person and as a learner. They were asked to describe their educational journey from school to the ME module; their age, ethnicity and anything else they considered relevant

about themselves; what they had learnt about themselves as a ME student, what they found challenging and what they had done differently to improve. This allowed them to share any details about being in a non-traditional group that was perhaps not recorded on their student record, but also enabled them to explain if they felt any specific challenges has arisen as a result of their background.

Sections 3 and 4 focused on the interviewee as a writer. They were asked about their feelings and actions in relation to the ME assignments, and what aspects of this writing they were most confident with. Similar questions were asked in more than one way so that interviewees had opportunities to provide unexpected or nuanced responses. For example, they were asked the open question 'How did you achieve this progress?' and then they were provided with examples of support within the module (e.g. tutorial feedback, videos, a summary of main ideas) and asked which were useful or unhelpful, and why.

The final section asked about advice they would offer to other students or the module team. All sections included prompts and probes to facilitate interactive meaning making.

Analysis

The first four interviews had a loosely-structured analysis in Phase 3. After reading the transcripts, the project team identified themes prevalent in the data that related to support and resources. These preliminary findings were brought to a module production team meeting (see impact below).

The whole data set consisted of transcripts of twelve 30-60 minute interviews, analysed during Phase 5. The analysis extended over a longer period than planned due to ongoing module production and two periods of parental leave. An initial analysis by our AL collaborator summarised student responses against codes derived from the interview questions. Between November 2021 and May 2023, these summaries were used to create a new set of codes, grouped under Difficulties and Supports. These included concept-driven codes (Roulston, 2010)

such as *Difficulty: Unfamiliar – personal positioning,* and data-driven codes such as *Difficulty: Mathematics*.

The transcripts were then re-coded using Nvivo and this coding was used to identify themes. Following Braun and Clarke (2006, p. 82), we conceptualise themes as patterned responses or meanings within the data set that capture something important about the data in relation to the research question.

The set of four themes in relation to *Difficulty* are shown in Figure 1. Text was coded to *Difficulty* if it reported unpleasant or unfamiliar experiences or was cited as a challenge or an aspect to improve on. Different aspects of complex themes are shown as subthemes.

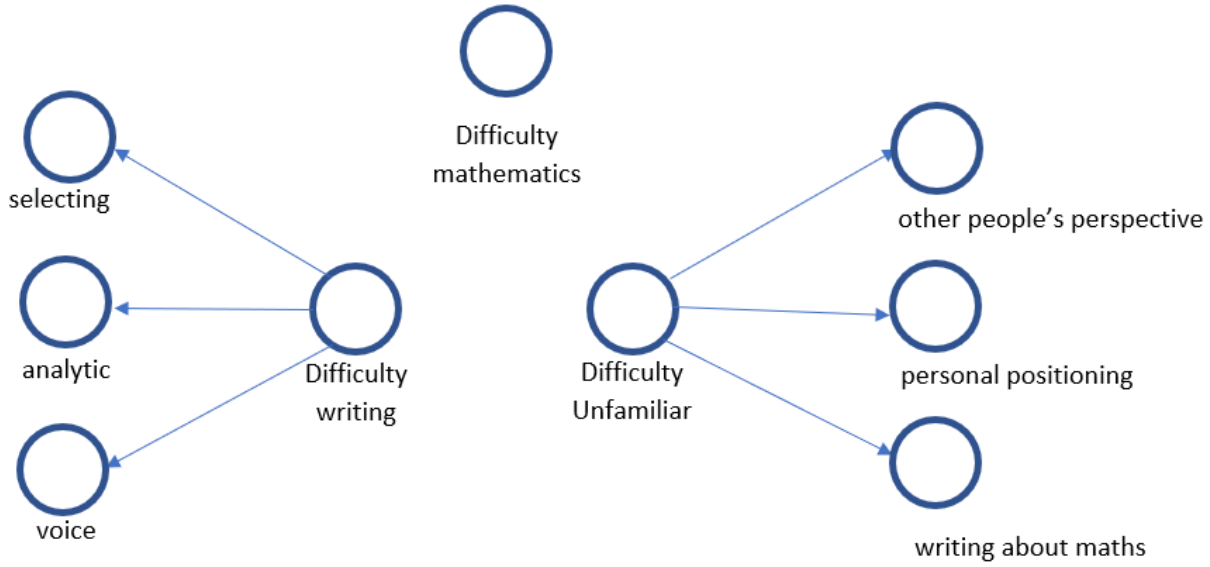

Figure 1: Themes and subthemes related to Difficulty

Another set of four themes (Fig 2) focused on Support, with subthemes showing either the source of that support or aspects of its nature. Text was coded to Support where participants talked about strategies or resources that either contributed to improved attainment and/or satisfaction or might have done so but actually did not.

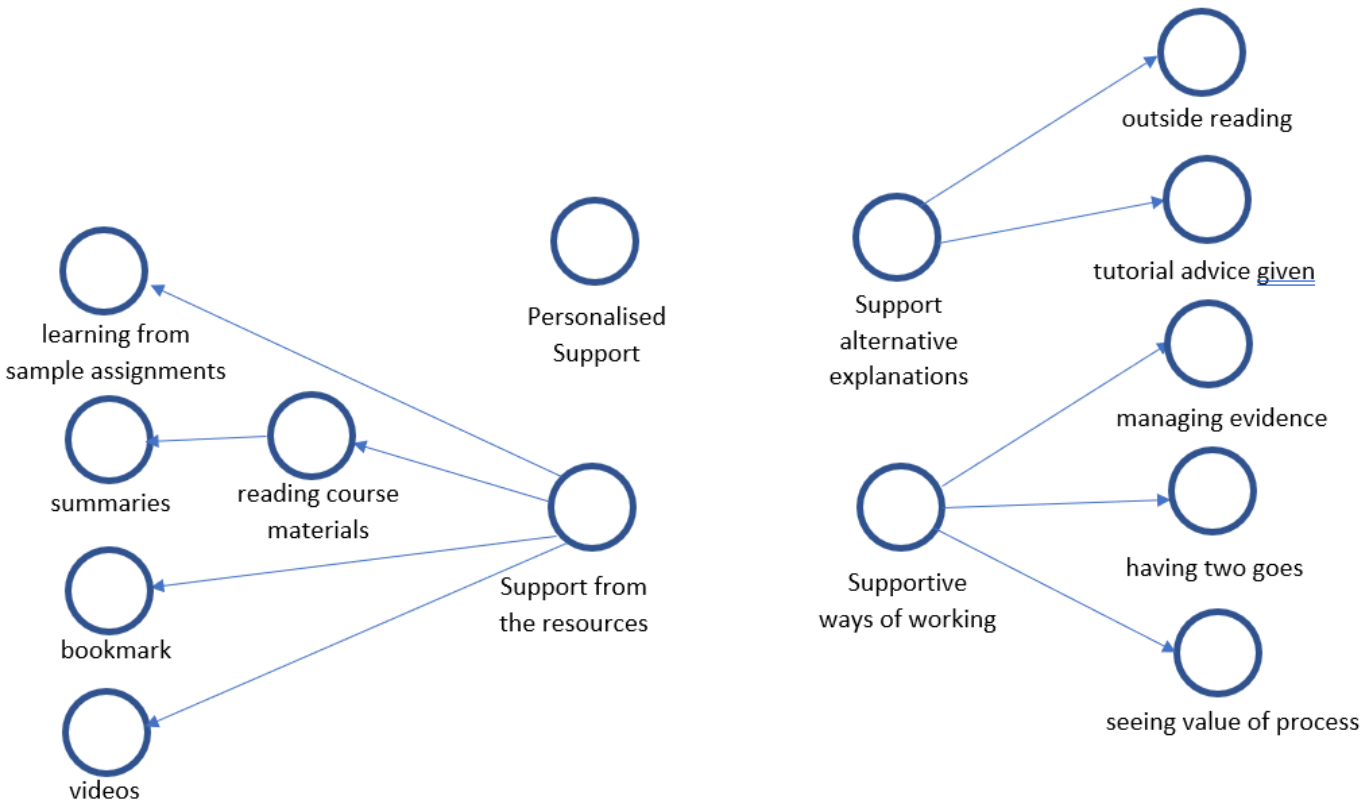

Figure 2: Themes and subthemes related to Support

Dissemination

We had originally planned dissemination activities at three levels: within ME, within the OU, and externally. The above constraints on staff time meant that only ME and OU dissemination have happened before this final report. The project team fed into the production meetings about assessment design for ME321 and fed consistently into ME322 production since one author was the production chair.

We plan three further activities: circulating this report to all ME ALs and to the research participants; writing a student-and public-facing summary for our Mathematics Education blog; writing a paper for a mathematics education journal.

Findings

Six main findings are presented here, prioritising those that have led to impact on module design.

Difficulties

1. **Unfamiliar:** Initial difficulties in mathematics education writing lie in the unfamiliar combination of writing about mathematics, about oneself and noticing other people's perspectives:
    - All but one student described a shift from writing down a mathematical solution to writing *about* the process of doing mathematics. For example, Sorcha described her first essays: "I just wrote exactly what I did and I was more concentrating on completing the task than I was thinking about what I was doing or the processes". Students had not appreciated that writing about mathematics involved a wider and more open register: "you kind of thought you knew mathematics as a language, but now there is a whole new teaching language" (Myriam).
    - All students cited writing about themselves as unfamiliar. Several students initially experienced this as a move to writing about "feelings", a "diary" or "highlight[ing] my own weaknesses." and only later recognised it as an analytic approach. Several students strongly disliked being "forced" to question their own activity because they had a strong preference for one way of learning or teaching mathematics: "because it was about myself and because I felt that it was challenging my learning preferences – that was quite difficult!" (Hannah).
    - Needing to observe and analyse how others learnt mathematics was another new experience. Some students considered this *more* difficult than writing about themselves but around half the students found this a support for noticing their own habits. Several mentioned revelatory tutorial experiences of working on tasks: "we

had all looked at the exact same question, the exact same time, but we had all approached it differently" (Steph).

2. **Mathematics:** Most students' ability to reflect is affected by mathematical task-difficulty. Students talked about learning to choose their tasks better, but with differing strategies: some avoided tasks they struggled with and others avoided easy tasks: "picking something you weren't confident in gives more to build on and more to kind of research and write about!" (Neil).

3. **Writing**: All students experienced continuing difficulties with writing, either with selecting material, being analytic or, less frequently, with writing voice.
    - Most of the students found they noticed more than they could write about and had to be increasingly selective in what to include: "just pick what I thought were the better elements and they got to stay and everything else, I got to say it, just not to anyone else, just to myself!" (Joanne).
    - It was not surprising that most students talked about striving to become analytic, since the word is used in the module and by tutors. Some understood this as explicit explanation for the tutor audience: "I was always putting half a point down; I wasn't elaborating enough" (Steph). Many talked about paying close attention to structure, specifically what each sub-question required: "I've realised that was when my feedback was very good when I had really considered the questions and whether I had answered them well." (Sorcha). For some, it remained uncomfortable to "separate out" a simple account of 'what learners did' from an analysis of how this involved mathematical thinking and learning.
    - Five students worked on developing a writing voice in the new language of the module. Louise described using her reading to set a "tone" and trying to "mirror that reflectiveness! And how condensed it is." These students appeared to set themselves the challenge of

finding a module-specific voice not merely to mimic the module content but knowing that it helped them with other difficulties such as expressing themselves precisely.

Support

4. The most significant source of support for improvers is personalised assignment feedback, particularly comments written on scripts: "it's just direct and exactly tailored for what you need to change" (Neil). Eleven improvers reported systematically consulting feedback when writing the next assignment and all mentioned the importance of positive feedback, for example: "he highlighted the areas that I'd written well and that helped me to see which parts of my thinking were useful in the context of the module" (Hannah).
5. Improvers considered they had learnt most from module materials that closely and concisely modelled the range of ways in which they needed to work for assignments. Videos of tutors analysing tasks were valued as demonstrating a way of acting, thinking and talking: "they did it so elaborately you know and were saying out loud things that you probably wouldn't say out loud" (Steph). However, the videos were also critiqued as "too perfect" (Myriam) in their focus on one module idea and not showing the messiness of real student work. Identifying relevant module ideas is part of students' analytic work; half the improvers mentioned using the summary chapters or bookmark to support them, in preference to re-reading detailed content. Over half argued for more samples of writing to guide them: "I would have liked to have seen just a paragraph of what reflective writing looks like" (Joanne).

6. Two supportive ways of working were prevalent: seeing the value of the analytic process (10 improvers) and having two goes (9 improvers). Hannah encapsulates the improvement that came from paying attention to the process of analysing and not mainly the end-product: "I don't think it was my writing so much as my thinking that needed to change to improve my writing." Improvers talked about allowing time for the

reflective and analytic process, contrasting “jumping in” with “breaking things down” and thus learning things “but also I realised that I knew things that I thought I didn’t if that makes sense” (Khadeeja).
In a related way of working, improvers allowed time to have ‘two goes’, effectively separating the initial analysis from the refining and re-editing of the assignment question. Some students first worked through the task, making notes with the assignment in mind, so that “when it comes to writing I’m not trying to think of the connections, the connections have appeared over the previous couple of weeks” (Joanne). Others “put it all down on paper first – everything you can think of” (Louise) but left time for redrafting because the editing process moved it from being descriptive to being analytic: “give yourself at least a week to reread it and improve it because you’ll get a third of your marks in that last stage” (Laura).

Impact

The impact of the project has been substantive for mathematics education modules, has started to influence teaching in other Mathematics and Statistics modules and has been disseminated at OU level.

Informing module activities

The project was designed to have a direct impact on the design of the new mathematics education modules ME321 and ME322 with first presentations in 21J and 22J respectively. The eSTEeM project team had production roles as authors, ME321 assessment lead and ME322 module chair.

An integrated approach to assessment

The major change to module content was integrating assessment activities as part of study. Their predecessor modules (those studied by the interviewees) were based on a course textbook that had no mention of assessment or writing. Each new module has a detailed 30-week planner and time for preparing assignments is allocated within this. While this principle had been agreed

beforehand, our project informed the sequencing and content of the preparation.

Two findings that particularly influenced the sequencing were the supportive way of working that involved *having two goes* at writing, and their emphasis on reading and re-reading personalised feedback. In ME321 and ME322, preparation activities for each assignment start 4-6 weeks in advance of the deadline. Each of the assignment questions has time allocated for starting and, separately, for finalising. Reading your tutor's feedback is scheduled as an activity before each new assignment.

To support authors in implementing this change for ME321, we developed a grid showing the preparation for each assignment over time and by content type (e.g. familiarisation, practice activities, work on task, work with learners, drafting, reading feedback, finalising, uploading). Re-using this grid for ME322 greatly speeded up scheduling. While the details are particular to mathematics education, the principle of breaking down and planning assignment preparation activities in this way is one we recommend to other production teams.

Finally, in terms of overview activities, improvers had recorded the value of having a summary of module ideas to refer to when planning and writing. The new modules are VLE-based so the 'bookmark' was developed into an interactive 'Module ideas map' that sits in the Resources area. It allows students to find a short definition of each idea and where it is first mentioned. Figure 3 shows part of the map from ME321:

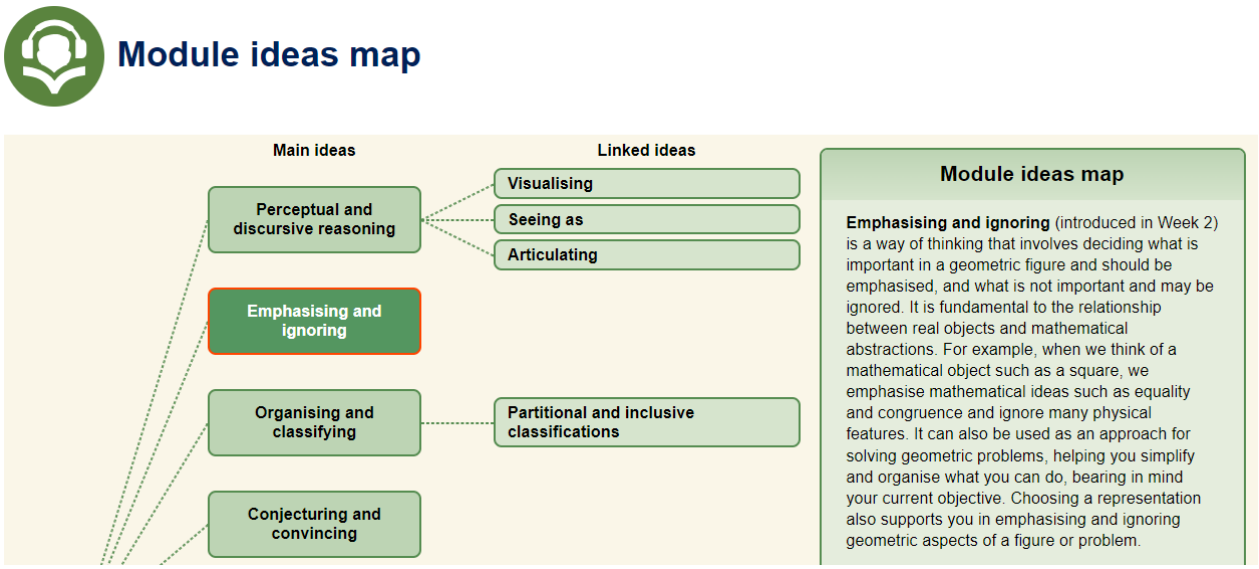

Figure 3 Interactive summaries of module ideas

Assignment design

Importantly, the project had brought attention to the significant complexity for students of integrating the range of ways of working on preparatory activities with the ways of thinking and writing required by each question part. As a result, the ME322 module team narrowed the focus of early assignments. For TMA01, students analyse and reflect only on their own mathematical work; for TMA02 they also analyse their learners' work but there is no explicit reflection question. Early feedback from this decision is positive: for example, the 22J Associate Lecturer Report commented on TMA01 that "all the students seemed to respond very well to the task although there needed to be more understanding about the module ideas from the weaker students". On TMA02: "a useful introduction to working with learners – again this is very tightly organised and structured which at times means the better writers have to be concise – the weaker writers are given the framework to succeed." Thus one outcome from the project is creating assignments that differentiate between students on different aspects of the learning outcomes: TMA01 on understanding, TMA02 also on writing skills.

These findings also supported the module teams' decision to explore asking students to answer one assignment question orally. For TMA03, students in both modules create and record a narrated Powerpoint presentation which analyses their work on a task. There are good employability reasons for this decision since teaching involves more use of oral presentation than writing. This project added to that justification since it showed that, even when students had become familiar with new ways of working (reflecting about and analysing, rather than just doing, mathematics), they experienced continuing difficulties in crafting written accounts. The oral presentation allowed them to focus on selecting what to say and how to say it in a format that is less concise and formal, but equally skilled. It is the way of communicating that has been modelled by tutors in tutorials, another source of support that improvers valued. The impact was thus to diversify the valued ways of communicating within the module, which is more inclusive for students who excel in oral rather than written communication skills.

Applying the lessons from the project, the production team provided detailed preparation activities about technology and about content. The (limited) feedback received has been very positive: "*I thought the PowerPoint presentation in TMA03 was a great inclusion. Obviously, to begin with, I thought 'oh no, what is this?' as I didn't have the foggiest regarding technology, but the guidance the module gave and the knowledge the tutors shared developed my skills and it became an enjoyable and useful experience*." (student on ME321 21J)

Teaching about writing

The project had found that students reported unfamiliarity with writing *about* mathematics and continued difficulty in distinguishing descriptive, analytic and reflective writing. This was the main support that they sought from tutorials. In response to this finding, new content was written for each module with explicit writing advice for students so that this support is not only found in tutorials. Topics addressed included: understanding what parts a, b, c of a question are looking for; reading about the difference between writing types; structuring

paragraphs; reading the marking criteria, examples of how to paste an extract of mathematical work as a figure within your writing and how to refer to it.

Modelling ways of thinking

The last findings that directly informed module design were the universal request for sample assignments, the critique of existing videos, and the improvement associated with *seeing the value of the process*. The module teams and Associate Lecturers have consistently argued against providing sample written assignments because they could encourage superficial imitations and restrict personal reflection. Combining these findings provided a compromise way forward. The *Teaching about writing* activities (described above) include only short extracts of writing, with commentary. However, the team decided that module content should very explicitly model the ways of thinking required to complete the assignments. This came into effect during the writing of ME322, with the result that most sections from Unit 2 onwards follow a structure of first describing work on mathematical tasks, then analysing using module ideas. This is a consistent pattern whether the focus is on students simply reading a description/analysis or being asked to do it themselves.

One project objective was to identify any potential for supporting students through resources *other* than written guidance. Students valued the existing team-produced videos, but their critique convinced the production teams that it was worth the expense and effort of creating new module videos showing school-aged children working on mathematics 'live'. These support the students in developing their analytic approach by providing examples close to their own experiences of working with learners.

Equally importantly, they also allow shared experiences of observing learners that permit peer feedback on writing. In ME321 students watch a video, write a short analytic response on the forum, then choose another student's response to reply to and comment on. This interchange is included as part of TMA01 so participation is rewarded. It is not possible to evaluate an isolated effect on writing, but including this activity has increased forum participation not only for

the TMA but in other threads (e.g. ME321 21J had 300 posts, over 2.5 x as many as its predecessor). It is another way of teaching through activity *other* than guidance.

Overall Student experience

The impact of this project was to inspire the design of module materials in ways we had not foreseen. We cannot follow up how specific changes informed by this project have affected student outcomes but we do know that, overall, the new modules have proved successful. ME321's pass rate was 81.3% in 21J and 78.8% in 22J, and ME322's was 77.3% in 22J, all 7+ percentage points above the corresponding Board of Studies average. There were no obvious differences in the performance of students from any specific group.

There is feedback available from a small number of 21J Student Satisfaction survey responses that points to the benefit of a well-structured module: *"I enjoyed this module very much! My development as an educator and learner was amazing. I had a fantastic tutor and the structure of the module was well prepared, easy to follow and informative. By far the best module I completed in the course of earning my degree, so happy I took it." (ME321 21J).* One comment mentioned the 10-hour study workload, which we recognise may feel demanding precisely because of its detailed structure. Another wanted more support at higher grades; *"Very happy with this module. The only problem is, after getting around 80% for most tmas it is not clear what is missing to get a pass 1."*

The module teams will continue to monitor and seek out student comments and reviews that can confirm or challenge the implications drawn from this project.

Impact beyond the modules

The project has helped the mathematics education group develop an expertise in developing activities that support and assess students in reflecting on their own learning. Our input was sought at the Mathematics and Statistics School

workshop 31/10/22 on embedding employability skills into modules across the Q31, W36 and Q46 qualifications. We have since advised M&S Level 1 module teams on developing assignments for 24J that include structured reflection and narrated PowerPoint presentations.

At the whole-OU level, our move towards authentic assessment was reported at an Assessment Programme Huddle and is being published as a case study in the OU Employability Best Practice Guide 2023.

For us, the value of the Learning from Improvers project has been in using students' knowledge to inform and improve future teaching

List of deliverables

Slides on Authentic Assessment for OU Assessment Programme Huddle. 17/3/22.

Workshop presentation: 'Effective reflective writing: learning from improvers', Open University's 3rd annual STEM Teaching Conference online. 2/3/22.

Poster presentation: 'Effective reflective writing: learning from improvers'. eSTEeM 10th Annual conference: STEM Scholarship for a Changing World – Disruption, Innovation and Impact. 30/6/21.

Poster presentation: 'Effective reflective writing: learning from improvers', online. Open University's 6th Biennial International Conference on Access, Participation and Success Race and Ethnicity Day. 15/3/21.

Module ideas maps in ME321 and ME322 .

Assessment Activities map for ME322.

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University approval processes

SRPP/SSPP – Approval from the Student Research Project Panel/Staff Survey Project Panel was obtained according to the Open University's code of practice

and procedures before embarking on this project. Application number 2020/1757

Ethical review – An ethical review was obtained according to the Open University's code of practice and procedures before embarking on this project. Reference number HREC/3847/Smith

A Data Protection Impact Assessment/Compliance Check was obtained according to the Open University's code of practice and procedures before embarking on this project. Reference (IAR) 28-04-098.


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