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ORIGINAL ARTICLE

Developing a new undergraduate pharmacology core curriculum: The British Pharmacological Society Delphi Method

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Abstract

The British Pharmacological Society (BPS) developed a new core curriculum for undergraduate pharmacology degrees. To do this, a modification of the Delphi Process was used. Initially, a pharmacology educator workshop was hosted to explore the core attributes expected of pharmacology graduates. We then developed these discussions into knowledge, skills, and attitudes statements and sent them, in the form of a questionnaire, to our Expert Group, which included pharmacology professionals from across academia and industry. In an iterative process, the Expert Group were asked to rank each statement according to how much they agreed it was a core graduate attribute. Where there was disagreement, statements were modified according to feedback. After three rounds of questionnaires, we had a draft core curriculum which was then finalized through a discussion workshop with the education community. In this workshop, practical aspects of curriculum implementation were discussed and the potential for the Society to develop resources to support it considered. The revised core curriculum is freely available on the Society website: https://www.bps.ac.uk/media-library-assets/library/undergraduate-pharmacology-core-curriculum. Several examples exist of the curriculum making an impact within and beyond the United Kingdom, where it has been utilized in a quality assurance context, as a tool for curriculum review and also to guide building new programs. Through a series of further expert workshops, the BPS Education and Training committee is currently developing more granular learning outcomes to accompany the core curriculum alongside recommended resources to enable delivery. In addition, this expanded curriculum is also being reviewed and updated to ensure it is fully inclusive and represents the diversity of pharmacology educators and learners worldwide.

KEYWORDS
assessment, curriculum, Delphi study, education, learning outcomes, undergraduate

Abbreviations: ABPI, Association of the British Pharmaceutical Industry; ASCEPT, Australasian Society of Clinical and Experimental Pharmacologists and Toxicologists; BPS, British Pharmacological Society; EDI, equality, diversity, and inclusion; FHEQ, Framework for Higher Education Qualifications; HEIs, Higher Education Institutes; IAMSE, International Association of Medical Science Educators; IUPHAR, International Union of Basic and Clinical Pharmacology; QAA, Quality Assurance Agency.

1 | INTRODUCTION

The ability to meet health challenges and produce new medicines and therapeutics relies on the development and growth of a scientific workforce that can innovate in a changing scientific and global health landscape.[1,2] As the science of drugs and drug action, pharmacology is a critical component of the sector.[2] It is a vibrant and varied discipline that is in demand, with graduates who go on to a range of different careers.[3] The breadth and depth of pharmacology is a strength but also poses a challenge when it comes to teaching.[4,5] As the primary learned organization for pharmacologists in the United Kingdom, the British Pharmacological Society (BPS) has a central aim to "promote and encourage the education and training of pharmacologists," and so, our project to develop a new core undergraduate curriculum was motivated by our growing understanding of how pharmacology is evolving and our desire to help lay the foundations for the discipline, educators, and graduates of the future.

The number of pharmacology undergraduates in the United Kingdom is growing, with 40% more students studying pharmacology at undergraduate level in 2015 compared with 2007, with an average of 6.4 applications per first year place.[3] Although this growth is seen across the sector, pharmacology sits above average in terms of growth rate per annum and is therefore performing favorably compared with other medical science disciplines. The number of pharmacology graduates also exceeded the number of Year 1 entrants, indicating that students are transferring into pharmacology programs from other courses.[3] Twenty-eight universities offered pharmacology degree programs in 2015, but these were advertised under 17 different degree titles, suggesting variability in what constitutes a pharmacology degree.[3] For example, the number of degrees solely called "Pharmacology" has decreased, with an increase in courses that are titled Medical Pharmacology or Applied Pharmacology. Whether or not the learning outcomes of these degrees differ substantively, or the different titles simply reflect a matter of branding, was not analyzed. It is not clear whether this reflects a change in teaching or a driver to demonstrate the "relevance" of the subject to future career paths.

Further, in 2014, as part of ongoing Society efforts to support education and training, pharmacology was included as a core subject and subject specialty in the Quality Assurance Agency (QAA) Biomedical Sciences Benchmark Statement.[6] Benchmarks describe the nature of study and the academic standards expected of graduates in specific subject areas and are used in the validation, development, and quality assurance of all Biomedical Sciences programs in the United Kingdom.

Taken together, these data show that students are interested in pharmacology, there is a large demand for places on pharmacology degree programs, and the number of students is increasing, with the potential for even more growth. The subject is also more visible in allied degree subjects, which further recognizes its broad value. Therefore, modern pharmacology is likely taught to varying levels of detail across a wide range of courses. Although growth is good news for the discipline, it can also create challenges for the delivery of education within new organizational structures, a challenge also identified by Australian pharmacology educators.[7] According to informal reports, pharmacology departments across the United Kingdom have been closed or subsumed into broader themed departments such as biomedical sciences, which can have the effect of decentralizing teaching with the associated risk of losing subject-specific expertise. We believed that working to reinvigorate a sense of community among pharmacology educators would help mitigate this risk and would help us engage in a new conversation about the future of pharmacology education.

Many pharmacology educators welcomed the QAA subject-specific benchmark but also requested further support in adding granularity to the benchmarks that would go further toward the development of learning outcomes. The Society did have an existing undergraduate curriculum, published on the website in 2004. It had been a useful tool but had become dated and risked falling short of supporting the new benchmarks. A further challenge was that pharmacology is a varied and evolving discipline: the focus of teaching (e.g., neuropharmacology and immunopharmacology) differs depending on the institution, particularly in the later years of undergraduate courses. Although this is entirely appropriate in research-informed programs, it does pose a risk that curricula begin to diverge significantly from the expectations employers have of graduates with degrees in pharmacology. Therefore, members of the Society began to use informal or Committee channels to canvass views on whether the core curriculum needed to be revised. Through the discussions that followed, it became clear that a new curriculum was needed to outline key concepts and principles, while trusting educators to interpret these for their specialized area, alongside institutional teaching and research strengths. Members also recognized the need for undergraduate education to prepare graduates for a wider range of careers, outside of the traditional, academic research path. Therefore, with the approval and support of Council, the Society embarked on a project to revise and update the curriculum. The project was led by this paper's coauthors with the cooperation of the Society's Education and Training committee.

The new curriculum needed to be relevant to today's pharmacology but also needed to be future facing, drawing widely across the discipline's scientific expertise and diverse professional paths. The process had to engage those who would use the curriculum, so we worked with the pharmacology education community to develop an educational tool that met their needs. Crucially, curriculum development also provided an opportunity to build a more cohesive and networked pharmacology education community.

Our aims were the following:

1. To develop a modern and relevant core curriculum for undergraduate pharmacology in a robust, inclusive, and transparent way, drawing consensus from across the discipline, while adapting to the research and teaching strengths of individual institutions.

2. To develop a curriculum that ensured graduates had the knowledge, skills, and attributes that met the requirements of the QAA benchmark statement and the expectations of stakeholders.
3. To develop a curriculum that was flexible enough to reflect the expertise and specialisms found within different universities.
4. To develop and strengthen the U.K. pharmacology education community.

This paper describes the approach we took to achieving Aims 1 to 3 and sets out the resulting curriculum. The fourth aim is much broader and represents an ongoing program of work. We are exploring how educators within established pharmacology courses can ensure that their programs are up to date and have relevant learning outcomes that meet the needs of employers in such a fast-paced area of academia, industry, and medicine.[8] Moreover, how can Higher Education Institutes (HEIs) ensure that they design quality curricula from the outset? It is intuitive that pharmacologists must have knowledge of current therapeutics and pharmacological tools, but they must also be able to innovate, discover, and develop new drugs and therapeutics, which requires knowledge of new techniques. In addition to subject and technical knowledge, future pharmacologists will also need the transferable skills to clearly and concisely present and discuss their research findings, to both their scientist colleagues and the lay public.[9] Further, many graduates do not pursue a career in pharmacology directly, but their knowledge and skills make them attractive to a range of employers.[10] The knowledge, skills, and attitudes of the curriculum should seek to produce excellent pharmacology graduates, but equally excellent graduates.

Framing the discipline and its contribution within a broader societal context is critical for developing greater bonds of trust and transparency between pharmacologists, pharmaceutical companies, clinicians, and the public and should be an embedded feature within pharmacology degree programs. Therefore, the challenge that arises for pharmacology educators is knowing *what* subject knowledge, *what* practical skills, and *what* transferable skills their undergraduates need to achieve and to what level? These questions extend into conversations about the role of the Society in supporting continuing professional development and lifelong learning. The interplay between education and relevant training is pressing given that pharmacology skills have been identified in skills gap analyses by the Association of the British Pharmaceutical Industry (ABPI).[11] Continuing to support engagement among educators and between employers and educators across the breadth of pharmacology will be a priority as the Society works to help shape pharmacology education and training for the future.

2 | METHODS AND STUDY DESIGN

To identify the pharmacology knowledge, skills, and attitudes that a graduate from a single honors pharmacology program should have attained by the end of their degree, we used a modification of the Delphi Process. This method was developed by the Rand Corporation in 1955 for use in defense during the Cold War[12]; its title comes from the oracle of Delphi of ancient Greece who answered questions in the form of further questions. The process is iterative and has been used extensively in curriculum development across a broad range of disciplines.[13–21] It is based on a framework that a series of questions are sent individually to a panel of experts and the results are compiled anonymously. The responses are then aggregated and shared with the group. An advantage of this method is that responses are anonymous, so no one participant has greater influence than any other. Another advantage is that, because the survey questions can be sent via email, respondents do not need to be geographically close. Indeed, this method has been used by members of the Society, Walley and Webb (previous Society President), to develop a U.K. clinical pharmacology curriculum[17] and more recently to develop a clinical pharmacology curriculum in Europe.[16] However, to our knowledge, the method used represents an innovation on those used previously in that, toward Aims 3 and 4, we held opening and closing workshops for course and program leads. The first of these aimed to develop the draft curriculum statements that would be used in the Delphi process, and the second, once the curriculum was complete, reflected on potential challenges of its implementation.

2.1 | Research team

The research team comprised all the present authors. M. J. W., A. Z., C. G., and I. McF. were involved in the decision-making process of the methodology. Each statement and decision was agreed by these four researchers to minimize individual bias and to triangulate the decision-making process. S. T. had a different role to the other researchers, as he was one of the expert panel members, so was not involved with the underlying methodology.

2.2 | Preparation of the curriculum statements for the survey

To initiate the process, key U.K. pharmacology education leads were identified using the Unistats website, and these individuals (31 people from 22 different U.K. institutions) were invited to the first curriculum development workshop, in central London. Over the course of the 1-day event, the project aims and method were introduced and explained, before attendees were separated into groups and asked to produce a list of core knowledge, skills, and attitudes statements expected of pharmacology graduates. In deciding this, attendees could use the previous curriculum and the Pharmacology subject-specific section of the QAA Biomedical Sciences Benchmarks as the basis for their discussions but were also encouraged to think "outside the box." M. W. and A. Z. facilitated these discussions. Ultimately, a final list of 79 statements were discussed and agreed by the workshop and went forward to be used in the Delphi Process.

2.3 | Selection of the Delphi Expert Group

To select the expert group, the roles and experience needed were first identified. These were the following:

- Program/Course Directors;
- Heads of Pharmacology and Clinical Pharmacology Departments;
- Experts from the pharmaceutical industry;
- Clinical research and education professionals;
- Basic research and education professionals;
- Recent graduates; and
- Other employers of pharmacology graduates.

Following the September 2015 workshop, expressions of interest were invited (in the form of a personal statement) to join the Expert Group. Invitations were circulated through Society newsletters, the Society website, and to education leads identified through the workshop and also members who had expressed an interest in education or relevant committees (e.g., the Society's industry committee). The call led to 42 people being accepted onto the Expert Group. The final group composed of 42 pharmacology professionals from across academia, industry, and related professions. According to the literature, the number of experts included in Delphi studies is variable.[12–18] Our number of participants was toward the higher end of what has been reported, with a high rate of retention through the study.[22] The balance by expertise is shown in Table 1.

TABLE 1 Delphi Expert Group composition

Area of professional expertise	Number with this experience*
Program/course directors	13
Heads of department	5
Pharmaceutical industry	7
Clinical	10
Education focus (≥50% of workload)	22
Some teaching (<50% of workload)	12
No teaching	4
Recent graduates	1
Other employers (this group only includes people who teach on healthcare courses, e.g., medicine)	8

*Each number represents the number of individuals out of the total with particular expertise or perspectives within pharmacology. Some people had experience of more than one area.

2.4 | Processes

2.4.1 | Delphi process preparation

Qualtrics survey software (Qualtrics) was used to administer the Delphi process, where the software generated the questionnaire and disseminated a link to it via email to our Expert group.

Experts were asked to rank each of the 79 statements on a 5-point Likert scale according to how important or unimportant they thought the topic was in pharmacology. We asked the panel to consider how the statements should apply to graduates from undergraduate degree programs where pharmacology is a named, substantive component. At this stage, we also asked them to consider the statements without regard to resource implications or other potential restrictions (e.g., some institutions do not have access to in vivo facilities for teaching, but we wanted the experts to consider whether this was a necessary outcome without being hindered by an individual institutions ability to provide a direct in vivo learning experience). Experts were also asked to comment on any statement that was unclear and provide any new statements of core graduate knowledge, skills, or attitudes that they felt were not represented in the questionnaire (Figure 1). Importantly, everyone on the group had an equal voice. For example, if a comment was raised by one person alone, this was sufficient to trigger a new statement to be tested in the next round. All input was anonymous, and with the exception of A. Z., the research team were blind to who had made comments.

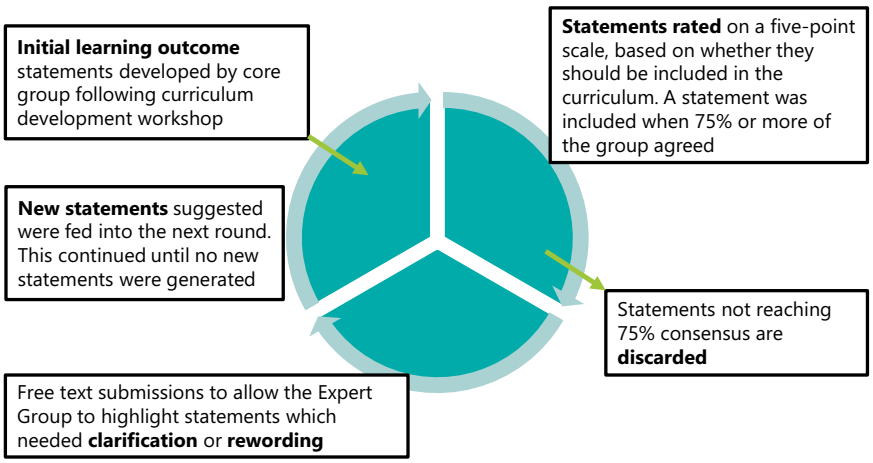

FIGURE 1 The Delphi process used in the generation of the curriculum. Following an initial curriculum development workshop, initial learning outcomes were fed into the Delphi process. After three rounds of questionnaires, we had a draft core curriculum which was then finalized through a discussion workshop with the education community

2.4.2 | Delphi process analysis

Where a statement was ranked as "fairly" or "very" important by 75% or more of the group, it was considered part of the core curriculum. We chose this threshold of consensus because it is midpoint in the range of what is frequently reported.[22] Where a statement scored lower than this, it was rejected.

The research team also analyzed the free text in each section, identifying where new topics were raised and where the Expert Group asked for clarification or rewording. The research team then met to develop new statements and reword existing ones where necessary. New statements, and those that had been significantly reworded, were then sent to the Expert Group to review in a second round Delphi survey. Three rounds of the Delphi process were run in total, stopping when no new statements were generated by the group (Figure 1). The research team met a final time to review the statements and edit on a very limited basis, according to syntax. In total, we generated 32 core knowledge statements, 21 core skills statements, and 18 core attitudes statements.

3 | RESULTS

3.1 | The BPS revised undergraduate core curriculum

3.1.1 | Core knowledge

Having successfully completed an undergraduate degree in Pharmacology, graduates will have knowledge and understanding of the following:

- Related disciplines;
- Life sciences (e.g., molecular biology and physiology);
- Relevant mathematics;
- The basics of medicinal chemistry, including the principles behind structure activity relationships;
- How related disciplines can yield insights in pharmacology and vice versa;
- Theoretical principles of drug action;
- Drugs that can be used in health and disease, giving examples from body systems;
- How drugs interact with their targets, including drug-receptor theory;
- Pharmacodynamics (molecule to whole organism);
- Pharmacokinetics (absorption, distribution, metabolism, and excretion);
- How physiological and pathophysiological processes are affected by drug action;
- Pharmacogenomics;
- Principles of toxicology and their application in safety pharmacology;
- Principles of translational research and experimental medicine;
- Methodological principles;
- Qualitative and quantitative statistical tools and analytical methods used to interpret pharmacological data;
- The scientific method (hypothesis formulation, hypothesis testing, experimental design, and experimental analysis);
- Appropriate and emerging methods for interrogating the pharmacodynamic effects of drugs;
- Appropriate and emerging methods for interrogating the pharmacokinetic effects of drugs;
- Drugs as pharmacological tools in scientific research;
- The principles of reduction, refinement, and replacement in the use of animals in research;
- Drug discovery and development;
- The multidisciplinary nature of drug discovery and development and the pivotal role played by pharmacology;
- The stages of drug discovery and development;
- Principles of clinical trial design;
- How knowledge of pathophysiology can yield insights into drug targets and new therapeutic avenues;
- Emerging therapeutic avenues;
- The use of gene modification techniques in drug discovery and development;
- Commercial drug discovery techniques;
- How medicine formulation impacts on drug action;
- Regulatory processes to include medicine quality, safety, and effectiveness;
- The challenges associated with developing and assessing the efficacy and safety of new therapeutic approaches;
- The societal impact of the discipline;
- The ethical principles of research, including clinical trials and animal research (design, implementation, and reporting);
- How pharmacology relates to social challenges and public health;
- The impact of pharmacology on patient care with respect to the safe and effective use of medicines; and
- The various career paths and opportunities afforded by a pharmacology degree.

3.1.2 | Core skills

Having successfully completed an undergraduate degree in Pharmacology, graduates will have the following:

- Experimental techniques;
- Be able to formulate a scientific hypothesis;
- Implement principles of good experimental planning and design;
- Identify the most appropriate statistical approach;
- Be able to make appropriate decisions about methodology when designing a study;
- Be precise and accurate when performing core laboratory skills;
- Carry out experiments following principles of Good Laboratory Practice;

- Be able to use quantitative methods to collect, process, and present data;
- Be able to use in vitro techniques in pharmacology;
- Have the necessary theoretical and/or practical training to be able to use in vivo techniques in pharmacology;
- Data handling and analysis;
- Identify and use information from appropriate and reliable sources;
- Integrate information from a range of sources and critically evaluate it;
- Apply and interpret appropriate statistical tests correctly;
- Use a common statistical software package;
- Accurately record and reference source material;
- Analyze and interrogate large datasets;
- Working practices;
- Keep up to date with the relevant literature and developments in pharmacology;
- Perform research efficiently through good planning and management;
- Organize and accurately record information, for example, in a laboratory book;
- Work independently;
- Work constructively in small groups or teams; and
- Communicate effectively to scientific and nonscientific audiences (including written and oral forms).

3.1.3 | Core attitudes

Having successfully completed an undergraduate degree in Pharmacology, graduates will have the following:

- A concern for detail and quality;
- A curious attitude and openness when interpreting data;
- A confident and adaptable working attitude;
- A willingness to accept a challenge;
- The courage to stand up for their principles under pressure;
- A resilient attitude in the face of failure or unexpected outcomes;
- The ability to work to the highest principles of scientific integrity, following ethical working practices;
- The ability to apply creative/innovative approaches to addressing complex problems;
- The ability to maintain effective working relationships and collaborations;
- The ability to work to fixed deadlines and manage pressure;
- A willingness to engage with developments across science and healthcare;
- The ability to identify employment opportunities and independently pursue personal career goals;
- The confidence and ability to apply their skills in a real-world setting;
- The skills for lifelong learning (e.g., independence, time management, organization and planning, initiative, and knowledge transfer);
- An appreciation of the societal relevance and impact of pharmacology;
- An appreciation of the value of public engagement and outreach;
- The ability to self-assess performance; and
- An understanding of how to evaluate risk.

The curriculum is available on the BPS website[23]: https://www.bps.ac.uk/getmedia/17b2b66f-92f7-4f64-93c6-5d8d7ddc9d00/Curriculum-2016-A4.pdf.aspx

3.2 | Society approval and current developments

To complete this first stage of developmental work, a broad consultation via email was conducted with all Society Members, no new potential statements were identified, and Council subsequently ratified the curriculum. It was launched at the Society's annual meeting in December 2016. Following launch, we held two further workshops. The first was for the original group of pharmacology education leads who were asked to identify any challenges to implementation and what support or resource would be required. The second workshop was an education working group where we invited original workshop attendees, the Delphi Expert Group, and other interested members to review and discuss online pharmacology resources. This work is ongoing, and we have recently addressed one of the key challenges (in vivo pharmacology education) through a separate Delphi project.[24] Current work through the Education and Training Committee is looking to develop broad learning outcomes for each of the consensus statements along with resources to support their delivery. This is being achieved through a series of Educator Network Meetings monthly through 2021 to ensure broad input from across the international pharmacology community. These subsequent steps aim to develop the functionality and sustainability of the curriculum and to embed it as a vital resource at the heart of pharmacology education to support creation, development, and quality assurance of pharmacology programs.

3.3 | Examples of practical use of the core curriculum

The impact of the core curriculum is evident through its use in a variety of contexts to guide the delivery of pharmacology education both within the United Kingdom and beyond. To date, the breadth of uses that the authors are aware of include the following:

- Quality assurance of existing curricula;
- Employment within an overarching curriculum review framework;
- Guidance for building new U.K. and European pharmacology programs; and
- Providing reference for students on what is expected of them.

Clearly, this demonstrates that the curriculum has directed educators, educational practice, and students across and beyond U.K. pharmacology, and the next steps in development of the curriculum will only serve to augment its functionality. In addition to

these indicated uses of the core curriculum, a U.K. Pharmacology Network meeting later in 2021 will aim to discuss uses of the curriculum to inform development of guidelines for its use to publish alongside it on the BPS website. Combined with the current review and expansion steps, this will set the core curriculum up as an invaluable asset for guiding and enabling pharmacology education.

4 | DISCUSSIONS

The BPS developed a new core curriculum for undergraduate pharmacology degrees, using a modification of the Delphi Process. Initial knowledge, skills, and attitude statements were developed through a pharmacology educator workshop and then sent to an Expert Group, which included pharmacology professionals from across academia and industry. After three rounds to agree assessment of statements, the draft core curriculum was finalized through a discussion workshop with the education community.[23] The core curriculum is designed to guide pharmacology educators in the development of their degrees and is regularly reviewed by the Society to ensure currency. Through the process of curriculum development, questions arose from pharmacology educators, students, and employers, which we discuss below.

4.1 | Curriculum or syllabus?

The new curriculum is not a syllabus.[25] It is not intended to be prescriptive. Educators should use their own academic judgement, experience, resources, and knowledge of their students' needs in interpreting the curriculum and applying it to their program. It also gives institutions the opportunity to play to their strengths in terms of the focus of their curriculum, particularly in later years.

4.2 | To which degrees does the curriculum apply?

The curriculum is intended for single or joint Honors BSc degrees for which pharmacology is a named, substantive component. In the future, the Society will be considering how and to what extent the curriculum can be used to inform clinical and postgraduate pharmacology training provision. Additionally, we have discussed with colleagues in the Heads of Universities of Biosciences (part of the Royal Society of Biology) on how it can be used to support degrees that contain some pharmacology but where pharmacology is not named in the degree title. This is because the QAA benchmarks for Biomedical Sciences include pharmacology as a core subject to any biomedical sciences degree.[26]

4.3 | How can the curriculum be delivered at an institution with varied or uneven resources?

As stated the above, the curriculum is not a syllabus; it is a *guide* to developing and updating programs. Each HEI, School, and Department has different strengths and resources. This necessarily means that individual programs will draw from some areas of the curriculum more than others. This diversity makes each program unique, something that we view as a strength within the field allowing each university to create curricula which are aligned by central criteria but still offer flexibility and tailoring. Indeed, the curriculum is not designed to constrain HEIs, rather empower them to develop their programs around the areas they excel in.

With that in mind, the statements defined through the Delphi process and outlined in the curriculum have been identified by our Expert Group as core to any degree with pharmacology in its name. Therefore, we feel that in order to deliver a program that meets the needs of graduates and employers, each curriculum element should be addressed in a way that is reasonable in view of resources. Furthermore, the curriculum will also be supported by a significant practice and resource sharing education platform, which will become a central component of the BPS education efforts in the coming years. Education-themed workshops have become established as an annual offering from the Society with a view to sharing practice around delivery of the curriculum, considering review of the curriculum statements and as a means of maintaining a sustainable, inclusive, and interactive education network across the Society.

4.4 | Should not good pharmacologists know more than what is in the core curriculum?

In our Delphi process, the Expert Group was asked to keep in mind what *core* knowledge skills and attitudes to expect from new graduates in pharmacology. Again, in view of the strengths of individual programs and individual student module choices and interests, certain areas of expertise may extend beyond "core" curriculum.

In addition, it is important to view the curriculum's content through a lens that is adjusted to the appropriate level. What *level* of expertise can reasonably be expected of a new BSc graduate? According to the QAA Framework for Higher Education Qualifications (FHEQ), this corresponds to Level 6.[6] We encourage users of the curriculum to review the FHEQ framework and, in particular, to contrast Level 6 with Level 7 (Master) and Level 8 (Doctoral). Only by considering the curriculum and the FHEQ framework together can the complete picture be gained and reasonable expectations of graduates be set.

4.5 | What about the QAA Benchmark for Biomedical Sciences?

The QAA Biomedical Sciences Benchmark Statement[26] includes core biomedical science knowledge, understanding and skills, graduate and transferable skills, and a subject-specific section on pharmacology. In our view, the Society curriculum builds on these benchmarks and "fleshes out" their meaning in a more specific pharmacology context. Therefore, the Society curriculum should be used alongside the benchmarks to define what is required in a pharmacology program.

4.6 | How does this fit with the global pharmacology landscape?

Internationally, pharmacology societies have focused more on developing pharmacology curricula for medical degrees, rather than for pharmacology science degrees, resulting in medical pharmacology curricula produced for the United Kingdom,[27] Australasia,[28] Europe,[16] the United States, and Canada.[29] The BPS was the first international pharmacology society to publish a core curriculum for pharmacology science degrees, and this paper details our most recent updating of the curriculum.[30] More recently, the Australasian Society of Clinical and Experimental Pharmacologists and Toxicologists (ASCEPT) have been developing core knowledge concepts for pharmacology education, and Aquifer and the International Association of Medical Science Educators (IAMSE) have developed core concepts for the "Basic Science Discipline" of pharmacology.[31] These pharmacology core concepts overlap significantly with the BPS core knowledge outcomes, adding validity to the BPS curriculum. Further, the International Union of Basic and Clinical Pharmacology (IUPHAR) Pharmacology Education Project topic list is organized around the core pharmacology principles contained with the BPS curriculum including pharmacodynamics, pharmacokinetics, and drug receptor action, together with comprehensive sections on clinical pharmacology, drugs, and therapeutics.[32] In contrast to the ASCEPT, IASME, and IUPHAR resources, a strength of the BPS curriculum is the inclusion of core skills and core attitudes in addition to the knowledge outcomes. The combination of knowledge, with skills and attitudes, provides a holistic framework for pharmacology knowledge, its application, and assessment.

5 | FUTURE DIRECTIONS: BUILDING AN INCLUSIVE AND DYNAMIC CURRICULUM

Pharmacology is rapidly evolving. Building a dynamic curriculum that keeps pace with new knowledge, innovations, and technologies requires that there be an education community invested in maintaining and updating it. The Society plans on periodically revising the curriculum to maintain freshness, relevance, and to keep pace with advances in the field. Following a recent review, the Society is developing more granular learning outcomes to accompany the core curriculum and collating and developing education resources to support delivery. In line with the Society's new vision for equality, diversity, and inclusion (EDI) in pharmacology,[33] we are using this review to examine how the curriculum can support inclusive pharmacology education. Students want to engage with the societal impact and implications of their discipline and recognize that underrepresented groups face barriers to accessing the benefits of pharmacology research. Ultimately, the Society wants to support educators and students to meaningful discussions about addressing inequalities in research and healthcare. To achieve this, review participants have been asked to explicitly consider EDI as they develop learning outcomes. These outcomes will then be reviewed by a new inclusive pharmacology education steering group, which has been established for the purpose of supporting the curriculum review and its subsequent implementation through making recommendations on resources and inclusive teaching. In parallel with the curriculum development period, we developed a thriving education strand at the BPS annual meeting, which includes education poster sessions, education oral sessions, a "boot camp" to discuss how to progress a career in pharmacology education, and a demonstration workshop where educators are able to showcase innovative teaching approaches and network with their peers.[34] In combination with the new annual education workshops, these approaches are a means of monitoring and continuing to evolve the core curriculum while also enabling effective delivery of its principles.

6 | CONCLUSION

In conclusion, the BPS has engaged the pharmacology community nationwide to develop a holistic core curriculum for pharmacology degree programs, which aligns with the QAA Benchmark Statements for Pharmacology. The curriculum is designed to be prescriptive enough to ensure that pharmacology degrees produce graduates with appropriate knowledge, skills, and attributes, while at the same time flexible enough to allow organic development reflecting the expertise and specialism found within different universities. The Society continues to engage with the education community to support the development and implementation of a dynamic and inclusive curriculum.

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DISCLOSURE

A. Z. is Director of Policy & Research at the British Pharmacological Society and was Head of Education and Engagement during the development of the curriculum. M. W., C. G., S. T., and I. McF. were all members of the Education and Training Committee at the British Pharmacological Society during the development of the curriculum.

AUTHOR CONTRIBUTIONS

M. J. W., I. McF., and A. Z. designed the study; M. J. W., A. Z., C. G., and I. McF. were involved in the decision-making process of the methodology and acquired and analyzed the data; S. T. was a member of the expert panel group. M. J. W., A. Z., and C. G. wrote the paper. S. T. and I. McF. critically revised the paper. All the authors have revised and approved the final version of the manuscript.

ETHICS STATEMENT

This project was developed with oversight from the BPS Education and Training Committee and ratified by the BPS Council. The project followed the British Educational Research Association (BERA) Ethical Guidelines for Educational Research. It was classed as low risk, so full institutional ethics approval was not required.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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