IPPOG RDB Proposal - Michael Gregory - Fall 2023

As discussed at length with the IPPOG chairs following the May IPPOG meeting in Sofia, I am submitting this proposal for work on the IPPOG Resource Database. The propositions and recommendations in this proposal are culmination of my work on the IPPOG RDB Working Group in 2021-22, discussions with the chairs in late Spring / early Summer, several months of research and various discussions with IPPOG Representatives and stakeholders which arose during collaboration on numerous other projects.

This report is divided into 6 sections, covering different aspects of my proposed work for IPPOG and the motivations behind it. The first 4 sections use research and a variety of sources to explain the current state of the RDB and explore ways forward, whereas section 5 and 6 summarize the findings, propose the creation of an IPPOG Education Expert and outline key tasks.

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1. History and Goals of IPPOG Resource Database

1.1 Purpose and Target Audience of RDB

To understand the current state of the IPPOG RDB, it can be relevant to recall the history of its development. Conceived in 2009 and created in 2011, "Initially called the EPPOG Best Practice Database, it was meant to be used by science institutions and laboratories for outreach and informal science education purposes." (p7 Gulejova, 2020) In other words, IPPOG members themselves, and their colleagues were the primary target of the RDB for the first decade of its existence.

Nearly a decade later, there was a shift, and "teachers and educational specialists are the primary audience of RDB, since 2017 " (Gulejova, 2020, p10). This shift to focus on formal education appears to be a shift from the core mission of IPPOG: "IPPOG's purpose is to raise standards of global outreach and informal science education efforts of particle physics" (https://ippog.org/mission). This is an ambitious goal to target a large new audience, and can benefit from involving expert teachers in the design process.

1.2 Teacher Involvement

It appears that teachers were heavily involved in curation during 2018-2020. Volunteers were recruited from CERN HST 2018 and 2019 to form a focus group of "IPPOG Friends", which were useful for curation and diffusion. Curiously, this group has been inactive since 2020, and none of these teachers appear to have been invited to participate in the RDB curation WG from May 2021 to November 2022. Their help could have played a key role, both in sharing the world load and to improve the relevance of the curation to the target audience of teachers. (After self-identifying as "the only teacher in the group" at RDB WB meetings, I eventually recruited two fellow CERN ITW 2018 alumni and oversaw their curation efforts in from September 2021.)

Reviving, recreating or expanding such a teacher group can play a key role both in development, curation and diffusion of the RDB if the goal is to continue to target teachers. However, it is worth considering that the original goal of the RDB was to share best practices between science institutions. Thus purpose seems to have been largely overlooked from 2021 onwards, with the curation, design, and discussions focused on formal education use. In my experience on the RDB curation WG 2021-22, our discussions and aims were to target the RDB for teacher use only. This view is consistent with IPPOG social media (ex. July 25th: https://www.facebook.com/photo/?fbid=610187121204953) and countless discussions I've had with various members of the IPPOG community.

1.3 Needs of IPPOG Members

Over the past year, through numerous particle physics outreach projects, I have been fortunate to collaborate with a number of IPPOG members and representatives, all of whom have been excellent and inspiring people. Many are researchers who spend most of their time in the lab, and have expressed an interest for recommendations and a list of resources to use for their outreach activities. Most are not aware that this was the original purpose of the RDB! None find the current RDB useful for this purpose.

In response, I have already started to share my Pilot "Resource Pack" of recommendations for Science Festivals and Outreach Events (Appendix 2), which has been met with much enthusiasm.

A recent JNIPER paper has described various personas of physicists and their key needs for successful outreach. At the top of their list (p6, Table 1, El-Adawy et al, 2023) is "a centralised resource hub" with a "searchable list of activities that are easy to implement". The IPPOG RDB can

address that need. The paper also identifies the need for opportunities to share ideas and findings with other practitioners and for science communication training. JNIPER addresses these needs through monthly coffee hours and with free online courses. These are excellent examples of good practice to meet the needs of outreach physicists, and could inspire similar projects for IPPOG to foster use of the RDB and communication between members.

Key points on History and Goals:

- Science institutions and labs (IPPOG Members) remain an important use-case for the IPPOG RDB. Specific care should be taken so that they have easy access to up-to-date resources and advice on how to implement them.
- If teachers are to remain a primary target audience of the RDB, they should be involved in the design, curation and diffusion to ensure that the database is relevant for them.
- "Resource Packs" are a solution to target different use-cases.
- To achieve both of these tasks, there is a need for an Expert Educator to lead the project, who has extensive experience both in the classroom and with informal education, and is actively involved in the use, creation and diffusion of particle physics resources.

2 - Design and Interface

2.1 Goals and Target Audience

Significant time and effort has already been expended to the current RDB design, so as I understand it, there is little desire to make significant changes in the immediate future. As such, I will avoid pointing out individual areas of improvement, but instead propose different elements of a design and evaluation process which can be used to inform future designs. The RDB should be designed to accomplish the goals which it is created to accomplish. Whether it is intended to target teachers, or as a way for IPPOG to share best outreach practices amongst members, or even as a historical archive of resources, the user experience should be at the centre of the design, and target users should be involved in the design process.

See **Appendix 1 - Summary of Best Practices,** which is an overview of resource databases and portals around the world. For each a couple of key points are listed which can be applied to the IPPOG RDB.

2.2 Evaluation/Testing

2.2.1 Basic testing for functionality

As obvious as it may seem, a number of problems can be identified simply by attempting to use the RDB and looking for what works well and what doesn't. Here is a non-exhaustive list of what can be spotted within a few minutes of trial use:

- A significant proportion or resources pre-date Higgs discovery, and would probably best be archived to a historical database of pp resources from the first decade of the 21st century
- Searching by language yields significantly fewer results than actually exist in any target language
- Title, description and author are not included in keyword search (ex. Search for "INFN" yields no results, and neither "Letizia Diamante" nor "De Quoi est Fait l'Univers" finds that resource of that name or author)
- Double-entries, such as SPRACE Game: https://ippog.org/ippog_resource_database/sprace-game

More examples could be included, but the scope of this proposal is not to list individual problems, but to outline methods for finding them. Simply testing for functionality can find enough problems to keep us busy for a while to fix them. For basic functionality, this testing can be done by the person(s) in charge of fixing problems. Once most basic problems are resolved, it can become more efficient to add focus groups and other user-generated feedback.

2.2.2 Focus Groups

Focus groups composed of potential users can play a vital role both in consulting pre-design, testing and feedback. Different focus groups would be appropriate to address the different needs of RDB users - for example, a working group composed of IPPOG members to advise on scientist-led outreach resources, and a revival of the "IPPOG Friends" teacher group to focus on classroom use. This would also have a benefit for diffusion, as explained by Barbora: *"A nice "spin-off" from working with teachers was the creation of the group "IPPOG Friends", a group of physics teachers interested to learn about IPPOG related activities, take part and disseminate them among their colleagues and students."* (p10, Gulejova 2020). Further focus groups could be added if other intended users are targeted.

Key Points on Interface Design

- RDB should be designed with users to accomplish goals with target users.
- Teachers and research institutions do not have the same needs. If both groups are intended users, then both should be considered in the design process.
- Several successful resource databases exist, and we can learn from their example

3. Curation

Curation can be an unexpectedly complex task, and take several times as much time as expected. This is not unique to resource database design, and has parallels in any system which strives to evaluate, classify and organise materials. A surprising number of parallels and relevant experience can be drawn from science fairs, video contests, peer juries, peer-review and grant applications. These comparisons allow me to draw on extensive personal experience for the first few, and from published literature for the latter.

3.1 Lessons Learned from IPPOG RDB Curation Working Group 2021-22

The experience of myself and the other 21 members of this working group can be used to improve future curation attempts. A number of issues arose, many of which were solved, and the lessons learned can play a key role in improving future curation.

3.1.1 Difficult and timing-consuming types of resources

The types of resources vary widely, which leads to problems with how to curate them and how to display them. One example is textbooks, which I feel should be considered beyond the scope of the RDB, and recommended separately, if at all. To curate a textbook fairly, at the very least the curator should obtain a copy of the book to familiarize themselves with it, and ideally to have experience using the textbook to teach from. I drew from my teaching experience teaching for one textbook and relied on colleagues for supplemental experience with others. It is difficult for non-teachers to assess school textbooks this thoroughly. Long videos and playlists were another example of a resource which could take many hours to curate properly, and which are susceptible to inconsistent curation, with some curators simply watching a few minutes and curating from a small sample of the whole resource.

3.1.2 Resource Websites

Resource websites and databases were another difficult point for curation. At one point, a quarter of the curation list was from INFN alone! I had identified this issue and discussed at length with Barbora and then the rest of the WG, and we came up with the solution of creating a section of the for resource websites and asking each of them to choose 3 of their best resources for us to include. This included Perimeter, JINR, INFN, Quarknet, S'Cool and others. Some of these were never added to the resource websites page, which was merged with a "members websites" page to give a hybrid mix where it's unclear which links will actually lead to resources. (Ex. top of the list is "TechnoMagicLand" in Sofia, which is a wonderful place, but has no particle physics resources on its website.) In many cases (Perimeter, JINR, INFN), the recommended resources don't appear to be included in the RDB.

3.1.3 Tags and Trigger

The time spent on curation was very inconsistent, varying widely both by resource type and by the effort that a curator wanted to commit. The system of tags was not clearly understood nor applied consistently. It was unclear how much time was expected of each curator, and how they were expected to curate different types of results.

The 2021-22 curation group was faced with a massive list of approximately 100 resources, most of which were collected via a Google doc during the May 2021 IPPOG meeting. This was then largely considered as a definite list, with all entries considered equal. Shortly afterwards submissions were closed because of the curation backlog. This was not an optimal method of collecting resource recommendations, because it was largely the first thing that popped into people's heads during the meeting, rather than a well-considered list of best practices that members want to share. There were omissions, double-entries, and some resources that aren't worth the time taken to curate them. There should have been some sort of a trigger mechanism to filter out a number of resources and reduce the burden on the curation team. Having Education Expert to lead the curation, it would be possible to start the task with a trigger mechanism to filter out resources and tidy up the list to reduce the burden on the duration team.

3.1.4. Teachers On Curation Team

In September 2021, in response to curation being behind schedule, I invited two teachers to the curation team, who I onboarded and supervised. Teachers have a lot of experience both with assessment and with comparing teacher resources, so they easily become particularly productive members of the team. Furthermore, they were able to draw from classroom experience and could benefit from finding resources potentially useful for their own teaching.

There are significantly more teachers in the world than there are particle physicists, so the pool of potential curators is orders of magnitude larger when teachers are used for curation.

For all of these reasons it would make sense if teachers were used for future RDB curation. It would nevertheless be important to have a working group of IPPOG members to steer the RDB development by making decisions concerning the goals, purpose, target audience and design of the RDB. But effort should be made not to overwork the RDB Steering WG with curation work, but rather to prefer outsourcing to teachers and other potential users.

3.2 Lessons Learned from Science on Stage National Festival Juries

As Science on Stage (SonS) France ambassador I had the pleasure of participating on the jury of five National SonS Festivals in September and October to help select the national delegations of

Kazakhstan, Serbia, France, Bulgaria and Spain. There are many similarities between judging teacher projects and curating teaching resources; I will summarize the most relevant to RDB curation.

3.2.1 Workload on Jury/Curators

Kazakhstan and Serbia both celebrated their 2nd National SonS Festival this year. A common pitfall for an inexperienced coordinator, whether for a jury or a curation team, is to underestimate the workload and time required to evaluate resources. At SonS Kazakhstan, pairs of jurors were initially instructed to spend 10 minutes each with 23 projects during a 4-hour window of time which included preparing and cleaning up from stage performances (we were all also brought there to perform science shows), travel to different parts of the venue, discussions and a lunch break. As an experienced juror, I insisted that each of these things would take more time than expected, so we halved the jury passing time to 5 minutes per project, and even then just barely finished in time.

In preparation for SonS Serbia, all jurors were asked to review all 43 projects in detail over the course of one weekend. This involved several documents per project, and an experienced juror could easily predict that each project would take 10-30 minutes to curate, and therefore the review task was unreasonable for the timeline. (Note that this kind of estimate for assessment times should come second-nature to experienced teachers who have years of experience marking student work.)

This inability to accurately estimate review times led to frustrations, both for the jurors and for the coordinators, just as inaccurate estimations of curation time led to IPPOG RDB curation consistently being behind schedule and curators feeling frustrated by the experience.

3.2.1 Normalisation of Curation

A strong point of SonS Kazakhstan, Serbia and Bulgaria was the coordination and normalisation of evaluations from different jurors. This took on several forms, but in all cases involved a meeting between all jurors to discuss the strengths of the projects selected for the national delegation, which drew on the expertise of all jurors to arrive at a consensus. This normalisation was missing from SonS France, where pairs of jurors evaluated several projects and gave numerical scores to each, which were directly used to rank projects.

After the fact, it became apparent that inexperienced jurors tended on average to give higher numerical scores, which resulted in the top three projects being selected by the least experienced pair of jurors, (ironically, they were Fabiola (IPPOG Scientific Secretary) and Emily (CERN PhD student)). In contrast, some of the most experienced jurors (Anne (Secretary General of EPS) and Nasko (SonS Bulgaria Ambassador)), aimed for a wider distribution of scores, and were upset that a lack of normalisation ended up penalising the projects they had judged.

3.2.3. IPPOG RDB Ranking System and Proposed Alternative

The same problem occurred with RDB curation when assigning an overall rating between 1 and 10 to be used for resource visibility and recommendation. No criteria were agreed upon, and indeed there was much disagreement whether any resources with a score lower than 6 should be included in the RDB anyway. Which then led to the paradoxes of why spend time curating resources won't be included, or why use a rating scale on which half of the scores will never be used? A better system for the RDB ranking would be a modified Borda scale (Borda, 1781), whereby each curator would be asked to rank the resources they curated, and each resource would receive a score according to their rank. An interesting modification could be that the more resources any one curator has curated, the higher their ranking will be, thus the ranking of a more expert curator will have a larger impact on the overall score.

3.3. Lessons Learned from Peer-Review

Whether for publication, grant review or even telescope time, peer-review is a time consuming process that can take a prohibitive amount of time to complete. As the number of applications/items to review grows, so does the problem, until it gets to the point that traditional review methods require prohibitively too much work. (p1 Merrifield, 2009) This problem has led to a number of innovative approaches, including a distributive approach to peer review as first popularised by Merrifield and Saari, and partially adopted by the National Science Foundation USA for grant reviews (Mervis, 2014)

While the particular method is not currently applicable to the RDB there are useful elements to apply to the RDB, namely evaluating the workload of evaluation, and methods of comparison drawn from electoral theory.

Key Points on Curation

- Curation is a more complex task than it initially appears.
- Complexity and workload increase with both the quantity and diversity of the resources.
- Different types of resources should be curated differently.
- Inexperienced coordinators will tend to underestimate curation workload. This can lead to frustrations and tensions as the project falls behind schedule.

4. Diffusion & Communication

4.1 Target Audiences

This is the most fun and exciting part of the proposal, especially for me as one of the most well-known science educators in Europe. When planning diffusion activities, it is important to plan for different target audiences. These include scientists, educators, students, general public and special interest groups. I will share some strategies for each. Each group will interact with the database in a different way, and will not have the same interest or use for different resources.

4.2 Resource Packs

One solution to this is the creation of targeted “resource packs”, which group together selections of resources for different use cases. Within days of coming up with the idea, it has already been met with enthusiasm by members of the IPPOG community. I have created a pilot resource pack for Festivals and Outreach Events (see appendix 2), which I have already shared with a couple of IPPOG Members who expressed immediate interest in the idea.

4.3 Teacher Networks

I have years of experience running workshops, courses, webinars and other meetings to share experiments and activities with teachers across Europe and beyond. I am French ambassador for the two largest science teaching networks on the continent - Science on Stage and Scientix. I retain strong ties with North America, where I grew up, including being an active member of the Perimeter Institute Teacher Network and the new JNIPER community, both of which have provided meaningful support with my particle physics projects so far. Teachers from around Latin America participate in my Spanish-Language Experiment Share meetings, and I have run workshops for hundreds of teachers in Ghana in collaboration with the Ghana Association of Science Teachers (GAST) and the Ghana National Association of Teachers (GNST), alongside Ghanian CERN ITW 2018 alumnus Chris Akpeloo.

4.4 Webinars

Webinars are an effective way to reach large numbers of teachers, such as this Scientix webinar where I helped share to Perimeter Institute Resource Portal, which is similar to what the IPPOG RDB strives to become: https://youtu.be/RPOHgEecLPU?si=bRNBLxoeZtBKN_So.

I hold the attendance record for Scientix webinars with more than 580 teachers registered for my June 2022 webinar My Favourite Experiments - More Low-Cost Experiments: https://youtu.be/LUkZ8ehz2hI?si=FZpJMmJzz_AZqxnZ. Such webinars could serve the multiple purposes of creating enthusiasm for the RDB (and particle physics in general) and training teachers how to use specific resources.

4.5 Articles

Articles in science education journals and blogs can also play a role in wider distribution of the RDB. One example is the article I co-authored for Scientix Blog to share The Quantum Prisoner, following their presentation as an inspiring success story at the the May 2021 IPPOG meeting: https://blog.scientix.eu/2021/10/the-quantum-prisoner-a-game-to-teach-science/. Another is this article I co-authored in Science in School for my Experiment Share meetings: https://www.scienceinschool.org/article/2022/my-favourite-experiments/.

4.6 Proposal for IPPOG Education Expert

It is of note that through these diffusion techniques I have successfully recruited teachers from all over Europe to attend courses and recurring meetings which I created as an individual teacher, with no institutional support. These techniques should be even more successful when used to promote the resources of an international collaboration such as IPPOG.

I propose the creation of the position of IPPOG Education Expert (or Teacher in Residence), which would encompass the proposed work on the RDB, but also include creating and overseeing a number of initiatives to bring IPPOG to teachers and to support and connect educational initiatives of IPPOG members.

Key Points on Diffusion and Communication

- Diffusion and communication should target specific use-case audiences.
- Themed “resource packs” are one solution for diffusing a subset of resources to specific groups, and are already well-received in pilot form.
- Webinars and articles are powerful diffusion tools to spread resources to teachers.
- Michael has extensive experience reaching teachers across Europe and around the world.
- IPPOG should hire Michael as an Education Expert to coordinate the RDB, its diffusion and other educational initiatives.

5. Conclusions and Ways Forward

5.1 IPPOG as a Spork

The IPPOG RDB was created as a means of exchanging best practice and resources between its members, scientific institutions and labs to facilitate preparation of outreach activities. This goal was largely lost when the focus was shifted to targeting teachers and students, however the need still exists. It is difficult to design a database which works well to simultaneously address the different needs of diverse groups and use-cases, without falling into the same fallacy of the spork. A spork has the bowl of a spoon and the tines of a fork, and is designed to be the best of both worlds, however rarely does a good job at being either. (Anyone who has tried to eat soup or spaghetti with a spork will tell you that the spork just isn't up to the task!)

To address the needs of different use cases, I propose the creation of targeted "resource packs", as can be seen in **Annex 2: Pilot Resource Pack - Science Festivals & Outreach Events.**

Without overhauling the existing structure and design of the RDB, these resource packs can be added on top as "best of" recommendations to make the database easier to navigate and more relevant to each target group. Furthermore, the creation of an IPPOG Educational Expert could facilitate personalised recommendations and advice for anyone planning outreach events.

5.2 Curation by Teachers

Curation is a complex and time-consuming process which is usually underestimated. It is best carried out by curators selected from the target audience, who have expertise in the resources they are curating, and who have interest in the ideas they gain from the curation process. If the RDB is to continue targeting teachers, curation should be carried out by teachers, led by an Educational Expert with extensive experience both in the classroom and with particle physics outreach.

A working group composed of IPPOG members should be created to steer the direction in which the RDB is developed, taking into account the goals and missions of the Organisation. **Members of this WG should not be burdened with the task of curation** (except in cases for which IPPOG members are the target users), nor with other tasks which could be borne by the Educational Expert or by volunteers. The goal of this group should be to deliberate and make decisions on the direction of the RDB in coherence with the mission of IPPOG.

5.3 Diffusion and Communication

After years of the RDB being "UNDER DEVELOPMENT" (aggressive use of capital letters copied directly from IPPG website: https://ippog.org/ippog-resource-database), its diffusion and widespread use is overdue.

Resource packs can be used to target different potential users, who can be targeted by different means. Scientists and institutions can be targeted internally through IPPOG communications. Teachers can be reached on a large scale through teacher networks, such as Science on Stage, Scientix, Perimeter Teacher Network, Exploratorium Teacher Institute Alumni, etc., all of which Michael is a member, if not the network's Ambassador for France.

Webinars can reach hundreds of teachers at a time. Michael holds the Scientix record for highest webinar attendance, and regularly connects with teachers across Europe through his monthly Experiment Share meetings.

Articles can be used to increase visibility. Large numbers of teachers can be reached through publications such as Scientix Blog and Newsletter, SonS Newsletter and Science in School. Social media can also be used to increase visibility, especially by including targeted groups of teachers and other potential.

“IPPOG Friends” or a similar teacher group should be revived or created. If led by an active, charismatic educator, this can become a very powerful tool for diffusion of resources as well as for feedback, and recruiting volunteers and collaborators for future projects.

There is a need for a resident IPPOG Expert Educator to coordinate development, curation and diffusion. **Through his proven experience, enthusiasm, karisma, sense of humour and boyish good looks, Michael Gregory is the best person to fearlessly lead the IPPOG RDB into a new golden age**, and to realise IPPOG’s dream “for the RDB to become the primary source of particle physics outreach material in the world!” (Gulejova, 2021. p11)

6. Proposal for the Creation of IPPOG Education Expert

This should be discussed and agreed upon in consultation with the Collaboration Board, however to start the discussion, it is useful to begin with some elements.

As discussed with the IPPOG Chairs, I am proposing to work on the IPPOG RDB from January to August to implement improvements as identified in this report. After August, the work should conclude with either:

1 - a plan for transition for other stakeholders to ensure the long-term success of the RDB

or

2 - a proposal for renewal or partial renewal of contract, according to resources available and the needs of the Collaboration. It is possible that after the initial 8-month period, which includes a significant amount of new work and creation, it may be reasonable to reduce the scale of the work but retain a long-term collaboration to ensure the continued success of the RDB and educational initiatives.

These exit strategies should be discussed with the Collaboration Board and decided at the Spring Meeting.

6.1 Key Tasks

Create and lead a new “RDB Steering” Working Group to guide the direction of the IPPOG RDB. The goal of this group should be to deliberate and make decisions on the direction of the RDB in coherence with the mission of IPPOG.

Create and lead a new curation group of teachers to process any remaining backlog and reopen submissions as soon as possible.

Assess the current backlog of curation and development tasks and develop an ambitious yet attainable plan to get RDB up to date as soon as possible.

Create resource packs for all use cases identified by WG or IPPOG members. Be available to advise resources and create custom packs and recommendations for any needs which should arise. (This can include some light resource creation, however this is generally beyond the scope and manpower of IPPOG.)

Diffuse the RDB and resource packs extensively through teacher networks and the scientific community through direct communication, social media, articles, webinars and courses.

Report regularly to WG and to the Collaboration Board.

6.2 Monthly Targets

January

- create new RDB Steering Group
- create new curation group of teachers and curation plan
- assess backlog of curation and development, create plan to get RDB up to date
- create resource packs for the first target uses: outreach events, Masterclasses and physics teachers
- diffuse Masterclass resource pack

February

- Start diffusion of RDB to teachers through articles and webinars
- Outline metrics to assess success of diffusion efforts
- Support use of resources to compliment Masterclasses and gather feedback on their use

March

- Use feedback from Masterclass resource pack to inform future development
- Report on progress of new curation group, update plan
- Continue diffusion of RDB to teachers

April

- Assess preliminary success of diffusion strategy
- Assess progress of curation group
- Create plan for needs of RDB moving in second half of 2024

May

- Report to Collaboration Board at Spring Meeting
- Submit for approval action plan for June to August
- Propose plan for long-term success of RDB beyond August. (Either propose renewal/partial renewal of contract or outline what is required of other stakeholders to ensure smooth transition for RDB goals to continue being met.)

Appendix 1 - Summary of Best Practices

Countless collections of education resources exist around the world, thus designing a resource database is far from a new problem. Much can be learned from a survey of existing databases, both collecting the best aspects, and identifying problems to avoid. Relatively little published research exists on this topic, and much of what is published is limited to quickly made short-lived collections of resources put together in Spring 2020 during the shift to online teaching in the Covid-19 pandemic.

In collecting best practices, it can be useful both to collect experience from the point of view of users and designers.
A distinction can be made between resource portals, made by an institute to share the resources they develop (ex. Perimeter Institute, Exploratorium, INFN, CIEMAT, ATLAS, CMS, etc.) and resource databases which are collections of resources developed by third parties (IPPOG RDB, Scientix, SonS Canada). The goals, target audience, curation, and development can vary greatly between these types of collections, however there is no significant difference in the user experience or interface design. Therefore, for the purposes of interface design, these two types of collections can be considered equally.

Here is a summary of some of the strengths and weaknesses of some of the best resource collections in the world:

Perimeter Institute: https://resources.perimeterinstitute.ca/
Resource Collection
Strengths: excellent resources
Weaknesses: login/checkout required for free download. Limited visibility of resources before committing to sign-up and download
Summary: Arguably the best physics education resources in the world, organised by thematic lesson compilations. The outreach and education department always includes teachers in residence, and works closely with their teacher network to develop resources through an iterative process.
Their portal is visually pleasing, searchable and can easily be displayed as sub-collections through a well-planned use of tags.
Key Points for IPPOG RDB:

- For teachers, organised by thematic lesson sequences
- Searchable in different target languages (vs. RDB all languages mixed)
- Good lessons to be learned on development & diffusion through “Teacher Network” and workshops/webinars
- Requiring a a log-in to access resources reduces potential users

Exploratorium Snacks Portal: https://www.exploratorium.edu/snacks
Resource Portal
Strengths: high-quality explanations of experiments, following clear, predicable format. Searchable and includes collections by subject and special themed collections.
Weaknesses: homogenous collection, so scope/format only applies to some times of resources for IPPOG RDB
Summary: The Exploratorium Teacher Institute is a world-class team of resident scientists and teachers who work together to develop high-quality teaching materials and professional development. Their Science Snacks collection is arguably the best known and trusted collection of low-cost science experiments in the world.
When improvements are made to the portal design, different test versions are made to isolate variables and test which works best with focus groups of teachers

Key Points for IPPOG RDB:

- Behind the scenes beta-testing for new improvements or iterations
- Good format to follow if we want classroom activities to follow a consistent format

Scientix Repository: https://www.scientix.eu/resources

Resource Database

Strengths: Huge number of resources (3197), minimum effort expended for curation

Weaknesses: Inconsistent quality of resources. Search/display does not make clear type of resource - lesson plan vs. activity, other, etc.

Summary:

The Scientix Repository has grown from a base of lesson plans created by teachers during online courses/MOOCS, but now also including other types of resources from a diverse range of stakeholders. Much of the content is created and curated as course requirements for Scientix MOOCs, which ensures a large quantify/variety of resources for similar needs. Curation is mostly done within the course by participants as part of their final assignment, thus familiarising teachers with other lessons, and reducing the curation workload of participants.

Key Points for IPPOG RDB:

- Interesting approach to curation by contributors
- Model could be used to generate new resources through a strong teacher network if IPPOG Friends or similar is ever revived or created
- Can be used as an example when considering large quantity of resources and user-based curation

Let's Talk Science: https://letstalkscience.ca/educational-resources

Resource Database (though most resources created by members of local chapters)

Strengths: large number of resources on diverse topics.

Weaknesses: A lot of clicking required to get to actual resource

Summary:

Network of science outreach clubs present in universities across Canada. Hands-on activities and lesson plans are created and shared for university students to teach guest lessons in schools of all levels. Organised by type of resource, then searchable within.

Key Points for IPPOG RDB:

- Consider different sections of website for different types of resource (ex. Textbooks don't need be be compared to posters or videos)

Institute of Physics IOP Spark: https://spark.iop.org/

Resource Collection

Strengths: high quality resources, large range of physics topics covered, well-organised, searchable

Weaknesses: page design old-fashioned, feels like reading a textbook from the 1990s.

Summary:

Thousands of high-quality resources for classroom use, including demonstrations, experiments, stories and misconceptions. Easy to navigate and search by age group and topic, this impressive collection covers the whole UK physics curriculum

Key Points for IPPOG RDB:

- This is an excellent example of a high-quality database, however, part of its usability comes from the consistent format of how resources are written-up and displayed, which is only reasonable for a collection of in-house resources.

ATLAS Resources: https://atlas.cern/Resources
Resource Portal (& database of links to external resources)
Strengths: outreach team very approachable for advice, feedback, creating new resources
Weaknesses: no search feature for resources (however can search the whole ATLAS website), some external resources don't lead anywhere clear (ex. ATLAS PhD Grant leads to CERN & Society portal, where it's more clear how to donate money than how to apply for an ATLAS Grant)
Summary:
Collection of internal and external resources presented together. This is a good example of a well-designed, functional resource database built with drupal/CDS and a number of technical constraints similar to IPPOG RDB.
Key Points for IPPOG RDB:

- Can be of use to as an example of a successful database built on a similar architecture

Appendix 2a - Pilot Resource Pack - Science Festivals & Outreach Events

See annotated version below for explanations of each resource.

Posters

ATLAS Posters: https://atlas.cern/Resources/Posters

CMS Posters:
https://cds.cern.ch/search?ln=en&p=6531_a%3APoster+and+collection%3ACMSOUTREACH&action_search=Search&op1=a&m1=a&p1=&f1=&c=CERN+Document+Server&sf=&so=d&rm=&rg=10&sc=0&of=hb

Stand/Quick Activities

ATLAS Colouring Book: https://atlas.cern/Resources/Colouring-Books
Also consider single-page ATLAS detector: https://cds.cern.ch/record/2765307/files/

CMS Activity Book: https://cds.cern.ch/record/2714290?ln=en

LHC Connect the Dots: https://connectdots.web.cern.ch

Workshop Activities

Perimeter Institute Escape Game - Igniting the Orbitron:
https://resources.perimeterinstitute.ca/products/igniting-the-orbitron-breakout-activity

Marinko's Rutherford Game - video: https://youtu.be/9CROa4gLSWY
Written description, figure 6:
https://blog.scientix.eu/2021/05/my-favourite-experiments-ghana-2021-teresco-resource-centre/

Chantal's Rutherford model: https://www.uv.es/fisicademos/demos/demo150.pdf

S'Cool Lab Mystery boxes: https://scoollab.web.cern.ch/mystery-boxes

Games

Particle Builder:
https://ippog.org/ippog_resource_database/particle-builder-board-game

Particle Guess Who: http://cds.cern.ch/record/2629312/

Particle Identities Quiz
Online version from S'Cool Lab: https://scoollab.web.cern.ch/particle-identities
Paper version from Letizia Diamante p2:
https://ippog.org/ippog_resource_database/de-quoi-est-fait-lunivers
I have seen this used with particle badges, such as these:
https://visit.cern/index.php/content/famous_particles, but personally I prefer the lower cost option of printing p1 of this ATLAS resource as stickers: https://cds.cern.ch/record/2765306/files/.

Appendix 2b - Pilot Resource Pack - Science Festivals & Outreach Events - annotated version

Posters

Posters can be downloaded from many CERN experiments, and with permission printed and used for outreach events. ATLAS and CMS are listed here as two popular choices. Also note that the schematics: https://atlas.cern/Resources/Schematics may be better than the general posters for some uses, in particular masterclasses.

ATLAS Posters: https://atlas.cern/Resources/Posters

CMS Posters:
https://cds.cern.ch/search?ln=en&p=6531_a%3APoster+and+collection%3ACMSOUTREACH&action_search=Search&op1=a&m1=a&p1=&f1=&c=CERN+Document+Server&sf=&so=d&rm=&rg=10&sc=0&of=hb

Stand/Quick Activities

ATLAS Colouring Book: https://atlas.cern/Resources/Colouring-Books
Also consider single-page ATLAS detector: https://cds.cern.ch/record/2765307/files/
This is a good introductory activity which can work for very young audiences with no prior knowledge, but can also be used as support material for more advanced audiences. In particular, the single-page ATLAS diagram with labels, can be a good support for virtual visits to follow where the guide is inside the detector. Page 12 of the colouring book is a good introduction to subdetectors, and could be appropriate support material for masterclasses.

CMS Activity Book: https://cds.cern.ch/record/2714290?ln=en
Pages 7-9 cover the parts of the detector and page 10 covers particle tracks and can be used as an introduction to LHC connect the dots or masterclasses.

LHC Connect the Dots: https://connectdots.web.cern.ch
Introductory activity for LHC data analysis. Pen and paper activity to trace a small number of particle tracks and identify particles.

Workshop Activities

Perimeter Institute Escape Game - Igniting the Orbitron:
https://resources.perimeterinstitute.ca/products/igniting-the-orbitron-breakout-activity
Escape game where participants need to solve puzzles about particle detectors around the world. Little prior knowledge is required, but the level of the game works best for high school students. The whole game takes approximately an hour, but puzzles can be removed or modified to make the game shorter or adapted for younger ages. The link provided is to the printable version, however an older (unsupported) .ppt version exists, which at times is easier when computers are available (ex. online settings).

Marinko's Rutherford Game - video: https://youtu.be/9CROa4gLSWY
Written description, figure 6:
https://blog.scientix.eu/2021/05/my-favourite-experiments-ghana-2021-teresco-resource-centre/
This can be set-up as a carnival-style game with participants throwing "alpha particles" at target nucleus. Introduces the principle of measuring cross-sectional area from number of rebounds, but is otherwise limited in scope. Can lead into Chantal's method following discussion of sources of error

and improvements. (A set of instructions will be written for the experiment guide to my "Particle Detectives" show, but for now I've included a video and brief description from an experiment blog.)

Chantal's Rutherford model: https://www.uv.es/fisicademos/demos/demo150.pdf
Alternate model of Rutherford experiment, which yields more accurate results.

S'Cool Lab Mystery boxes: https://scoollab.web.cern.ch/mystery-boxes
Nature of science activity from S'Cool Lab to teach about testing hypotheses.

Games

Particle Builder:
https://ippog.org/ippog_resource_database/particle-builder-board-game

Particle Guess Who: http://cds.cern.ch/record/2629312/

Particle Identities Quiz

Online version from S'Cool Lab: https://scoollab.web.cern.ch/particle-identities
Paper version from Letizia Diamante p2:
https://ippog.org/ippog_resource_database/de-quoi-est-fait-lunivers
I have seen this used with particle badges, such as these:
https://visit.cern/index.php/content/famous_particles, but personally I prefer the lower cost option of printing p1 of this ATLAS resource as stickers: https://cds.cern.ch/record/2765306/files/.
Note that these quizzes have limited pedagogical value, with the participants' identities having fairly little to do with the properties of the particles, however they can be a fun way to get participants talking about particles. Also note that for some demographics, the S'Cool Lab version seems to identify a large number of neutrinos.

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