City Research Online

City, University of London Institutional Repository

Citation: Zachos, K., Lockerbie, J., Brown, A., Terwindt, S., Steele, S., Kyffin, A., Jabry, B., Ng, C., Wolf, A., Goodman, P. & et al (2022). A multi-technique tool for supporting creative thinking by sports coaches. In: C&C '22: Creativity and Cognition. (pp. 601-607). New York, USA: ACM. ISBN 978-1-4503-9327 doi: 10.1145/3527927.3535199

This is the accepted version of the paper.

This version of the publication may differ from the final published version.

Permanent repository link: https://openaccess.city.ac.uk/id/eprint/28207/

Link to published version: https://doi.org/10.1145/3527927.3535199

Copyright: City Research Online aims to make research outputs of City, University of London available to a wider audience. Copyright and Moral Rights remain with the author(s) and/or copyright holders. URLs from City Research Online may be freely distributed and linked to.

Reuse: Copies of full items can be used for personal research or study, educational, or not-for-profit purposes without prior permission or charge. Provided that the authors, title and full bibliographic details are credited, a hyperlink and/or URL is given for the original metadata page and the content is not changed in any way.

City Research Online: http://openaccess.city.ac.uk/ publications@city.ac.uk

A multi-technique tool for supporting creative thinking by sports coaches

Konstantinos Zachos
National Centre for Creativity enabled by AI, City University of London, K.Zachos@city.ac.uk

James Lockerbie
National Centre for Creativity enabled by AI, City University of London, J.Lockerbie.1@city.ac.uk

Amanda Brown
National Centre for Creativity enabled by AI, City University of London, Amanda.Brown.1@city.ac.uk

Stephanie Terwindt
National Centre for Creativity enabled by AI, City University of London, Stephanie.Terwindt.3@city.ac.uk

Sam Steele
National Centre for Creativity enabled by AI, City University of London, Sam.Steele@city.ac.uk

Aimee Kyffin
Chemistry, aimee@chemistryteam.com

Bassam Jabry
Chemistry, bassam@chemistryteam.com

Clarence Ng
Chemistry, clarence@chemistryteam.com

Alex Wolf
Liberating Brilliance, alex@liberating-brilliance.com

Pete Goodman
F90, p@f90.co.uk

Neil A.M. Maiden
National Centre for Creativity enabled by AI, City University of London, N.A.M.Maiden@city.ac.uk

Sport Sparks™ is a new digital tool that has been researched and developed to augment the creative thinking of sports coaches when resolving challenges experienced by athletes. Most sports coaches work across multiple training sites and have limited opportunities and resources for creative thinking. The *Sport Sparks*™ tool was designed to provide ready-to-use guidance for creative thinking, via mobile devices, that is generated using automated natural language processing, rule-based reasoning and creative search. This short technical demonstration paper summarises and demonstrates with examples the different strategies and features implemented in *Sport Sparks*™ to augment coach creative thinking.

CCS CONCEPTS • Human-centered computing~Human computer interaction (HCI)

Additional Keywords and Phrases: co-creative AI, creative thinking, sports, coaching

ACM Reference Format:

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the Owner/Author.

C&C '22, June 20–23, 2022, Venice, Italy

© 2022 Copyright is held by the owner/author(s).

ACM ISBN 978-1-4503-9327-0/22/06.

https://doi.org/10.1145/3527927.3535199.

1 augmenting creative thinking in sports coaching

Sports coaching can be defined as the process of motivating, guiding and training individuals and teams in preparation for sporting events, careers or pastime activities. The need for creative thinking in sports performance is well-established. E.g., increased team creativity has been associated with goal scoring and progressing to later rounds of elite football tournaments [4]. As a consequence, research has sought to foster the creative capabilities of athletes in different sports. E.g., method principles for tactical creativity approaches for team sports have been proposed [7] and creativity has been conceptualized as a developmental resource in sport training activities – the exploratory and playful processes of discovering, exploiting, and originating unusual action possibilities that stimulated creative actions during training [10]. However, most of the reported research has so far focused on increasing the creative capabilities of athletes rather than coaches. Although large-scale creative processes have been used by coaching staff to, e.g., generate novel ideas to impact medals opportunities for Olympic teams [3], explicit support for everyday creative thinking by coaches has been missing. Therefore, to fill this gap, the authors researched and developed a new digital tool called *Sport Sparks*™ to support coaches to think more creatively about sports challenges faced by both individual athletes and teams.

2 the *Sport Sparks*™ tool and approach

Sport Sparks™ is a research-based tool designed to augment the abilities of coaches by automating the discovery of potential ideas with which to solve coaching challenges. It is a co-creative artificial intelligence (AI) tool (e.g., [5]) that implements machine intelligence to augment human creative thinking. Consistent with human-centred artificial intelligence (HCAI) approaches, it reframes AI to be "in-the loop" around coaches to support important qualities such as self-efficacy, creativity and social participation [13]. It is designed to implement the first two of what Shneiderman refers to as three fresh ideas – to deliver high levels of human control as well as automation, and to empower people with powerful tool-like appliances, rather than emulate human expertise [13].

In response, *Sport Sparks*™ was designed to provide sports coaches with high levels of control over the different forms of automated guidance to use to empower their creative thinking. These different forms were designed pragmatically, to empower coaches rather than to emulate their expertise. And because most professional coaches work under pressure and have little time, so it was also designed to generate multiple potential ideas quickly in outdoor environments using an appliance familiar to most coaches – an interactive mobile web application to use on their own smartphones.

During the development and evaluations of earlier *Sport Sparks*™ prototypes [6], sports coaches reported a range of needs, from support for real-time ideation during training sessions to learning existing coaching knowledge to develop new strategies. Therefore *Sport Sparks*™ was designed to support, in one tool, different problem solving strategies. These strategies included:

a) Transformational creative thinking to challenge current coaching practices using new rule-based guidelines that were generated automatically;

b) Exploratory creative thinking with existing knowledge about established and emerging coaching practices, using creative searches that discovered content and topics from related sports science publications;
c) Exploratory creative thinking with cases to resolve similar challenges, using creative searches that discovered semantically similar cases from a repository of good coaching practices;
d) Exploratory creative thinking with direction sparks to generate potential ideas quickly, using a new rule-based approach that generated partial ideas automatically in response to an entered challenge, and;
e) Collaborative creative thinking to share challenges and ideas with peer groups, using existing communication tools such as email with PDF attachments.

How *Sport Sparks*™ supports each of these creative thinking strategies is outlined and demonstrated in the remainder of this short paper.

3 how Sport Sparks™ augments creative thinking WHEN coaching

Each coach described the current situation and the desired outcome of a new challenge with natural language text, then used prefill options to select the type of athlete or team facing the challenge (e.g., *U18 (under-18 years-old) Player*) and other tags that best characterised the challenge (e.g., *Physical well-being*), see Figure 1. An automated topic extraction algorithm applied shallow natural language parsing techniques to extract the proper name, noun and verb terms from the description and disambiguated each term by discovering its correct sense according to the online lexicon at WordNet (e.g. that the term *match* is a *formal contest in which two or more persons or teams compete* rather than *a burning piece of wood or cardboard*), then returned an unordered set of stemmed topics that were input to the different problem solving strategies. An example of this guidance is depicted in Figure 1. A coach entering a description of a new coaching situation. The coach has entered a short challenge description, in this case about a slow recovery from a hamstring injury, and *Sport Sparks*™ has automatically extracted stemmed topics such as *hamstring* and *training programme*.

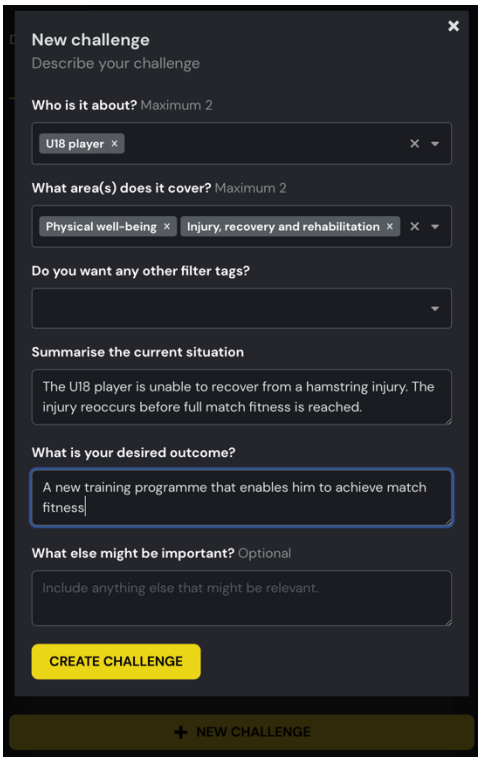

Figure 1. A coach entering a description of a new coaching situation

3.1 Transformational creative thinking to challenge coaching practices

To encourage transformational creative thinking, *Sport Sparks*™ implemented rule-based reasoning to generate what are called *imagine sparks*. These *imagine sparks* were designed to encourage coaches to challenge possible constraints and assumptions that limited their space of ideas, using a set of over 20 rules that codifed reported practices (e.g., [8]) for challenging constraints. At run-time, the tool automatically selected five of these rules, instantiated each with one topic randomly selected from the unordered set extracted from the description, and presented these five instantiated rules to the coach. The algorithm to generate imagine sparks is depicted graphically in Figure 2.

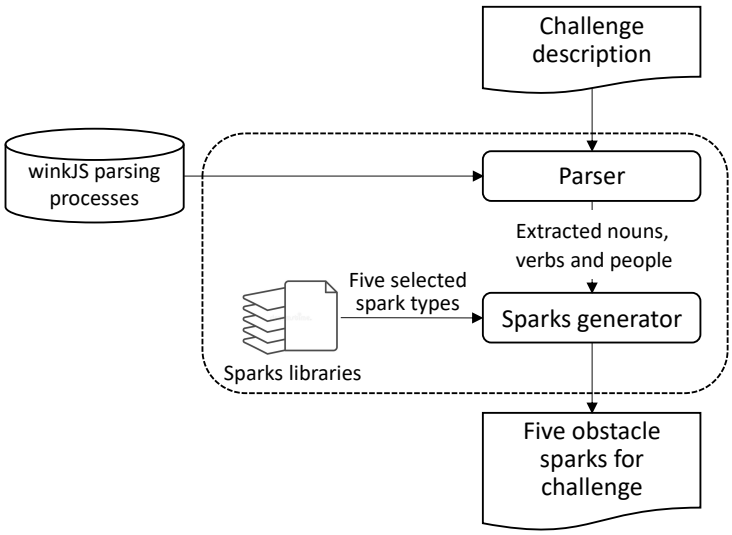

Figure 2. The rule-based reasoning algorithm to generate *imagine sparks*, as a means to encourage transformational creative thinking by coaches

An example of the output from this algorithm using the entered challenge from Figure 1 is shown in Figure 3.

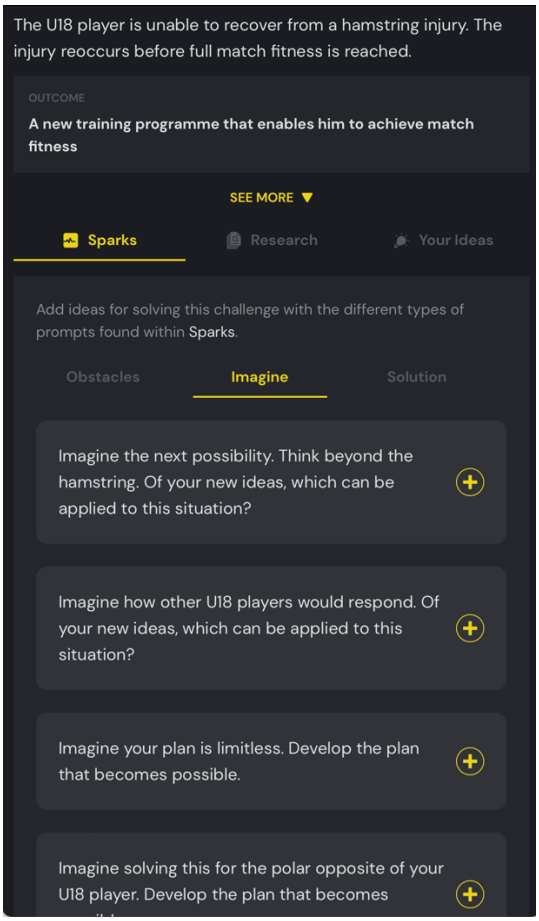

Figure 3. Auto-generated *imagine sparks* that are presented to encourage transformational creative thinking by a coach

Furthermore, at any point, the coach could select one or more constraints as the starting point for ideating, and refresh to generate and view another five constraints out of the many 100s of combinations possible. If the coach selected to ideate using one of the generated constraints, the tool opened a pop-up with automatically-generated partial idea expressed in natural language that the coach could edit to complete, see Figure 4.

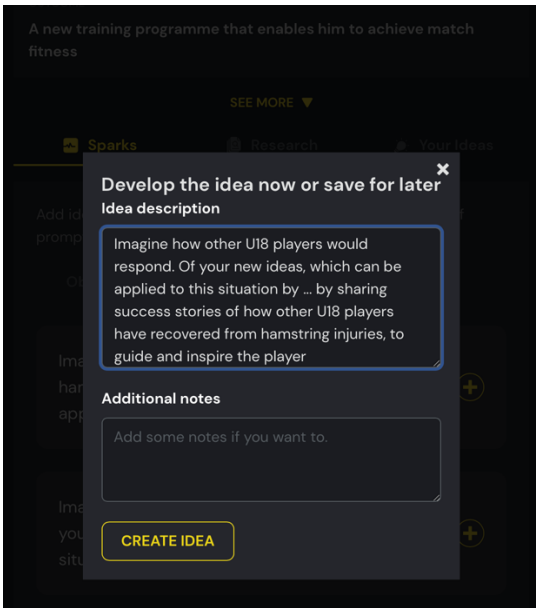

Figure 4. A presented partial idea automatically-generated from one selected *imagine spark*

3.2 Exploratory creative thinking with academic research knowledge

To encourage exploratory creative thinking, *Sport Sparks*™ implemented a creative search algorithm to discover academic sport science papers from curated sources, extract themes from these papers automatically, and used these themes to direct coach creative thinking. It used APIs to discover content from pre-selected sport science publications available via Google Scholar and Semantic Scholar, and exploited the returned content to extract topics to direct ideation using *research sparks*. The algorithm to retrieve this relevant academic research and generate the research sparks is described in Figure 5.

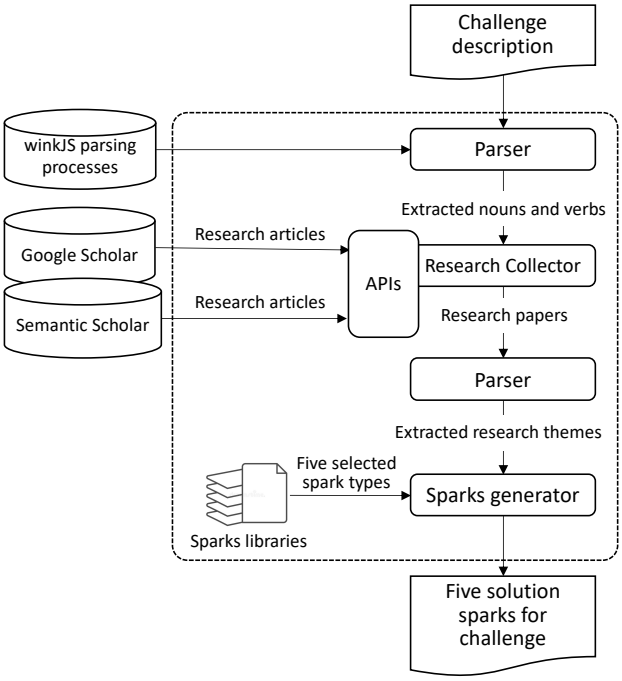

Figure 5. The algorithm to discover relevant academic content and generate *research sparks*, as a means to encourage exploratory creative thinking by coaches

Sport Sparks™ presents the retrieved academic research content, for the entered challenge depicted in Figure 1, for coaches to interact with and explore, see Figure 6.

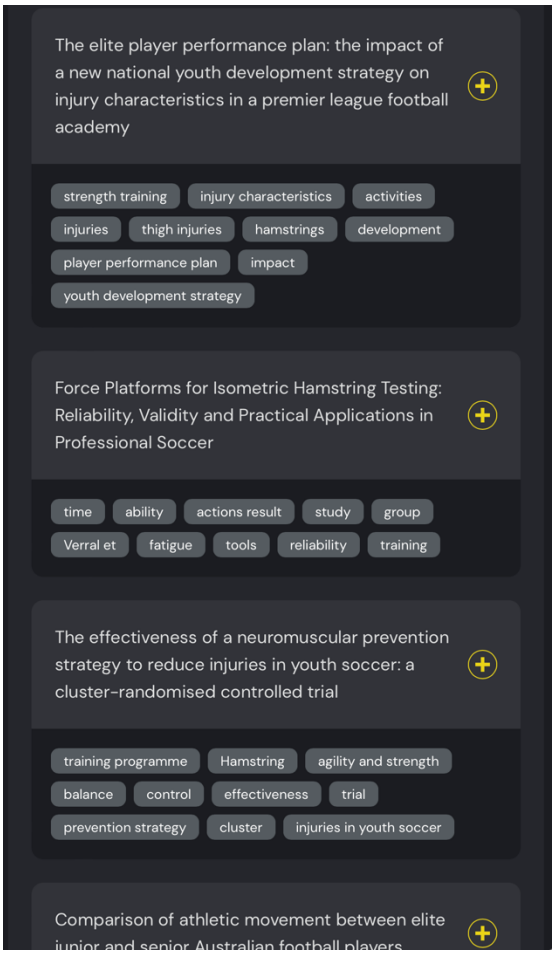

Figure 6. Automatically discovered research publication and topics presented to the coach to encourage exploratory creative thinking

To provoke further creative thinking using the retrieved academic content, another set of rules that randomly combined these extracted topics with topics extracted from the entered challenge to generate what are called *research sparks*. The coach could explore each spark and generate ideas related to it. E.g., by clicking on the topic *youth development strategy*, the *Sport Sparks*™ tool automatically generates questions that combine topics from the entered challenge and the retrieved paper, e.g., *If you focus on the youth development strategy and the U18 player, what new ideas emerge?* and *How can you rethink the U18 player's training programme with respect to the youth development strategy?,* as shown in Figure 7.

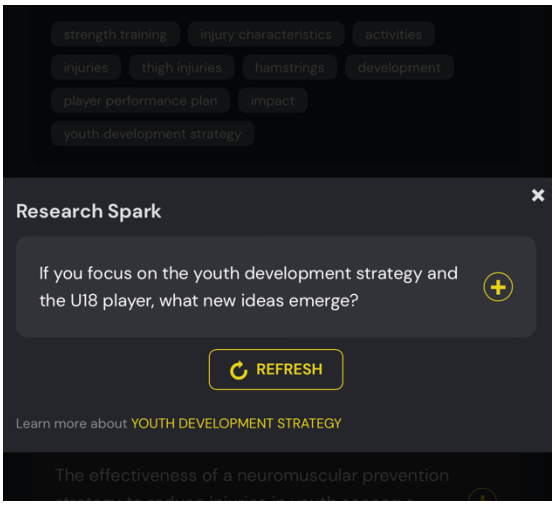

Figure 7. An example of a *research spark* automatically generated if the coach selects the topic youth development strategy

3.3 Exploratory creative thinking with good practice cases

A similar feature has been implemented to support case-based creative thinking to resolve similar challenges. The tool implements creative search algoirthms to discover similar cases from a repository of good coaching practices. It presents the discovered cases and extracted themes in a similar format to the academic papers shown in Figure 6.

3.4 Exploratory creative thinking with direction sparks

Sport Sparks™ also combined different forms of rule-based reasoning to deliver automated idea generation quickly. Rule-based expert systems have continued to be applied to solve real-world problems (e.g., [1] [2] [9]), therefore rule-based reasoning was also implemented to provide coaches with a controllable set of rules capable of boosting their cognitive creative thinking [12]. The co-design workshops [6] with experienced coaches were used to surface different sets of ideation rules that were codified then extended with content from relevant sport science publications on key topics such as athlete wellbeing [11]. The structure of these rules is depicted visually in the Ishikawa diagram in Figure 8. Using this structure, different new rulesets were designed to generate ideas automatically to encourage exploratory creative thinking by the coaches. Over 400 different idea generation rules were specified, each with a parameterized natural language description to instantiate with topics extracted from the entered athlete challenges and predefined conceptual space(s) to explore. Directions for the creative thinking encouraged by these rules included: *doing more or less of something*; *encouraging more mental preparation*; *asking parents to understand injuries better*, and; *rotating sides in training games to match ability and ensure competition is even*.

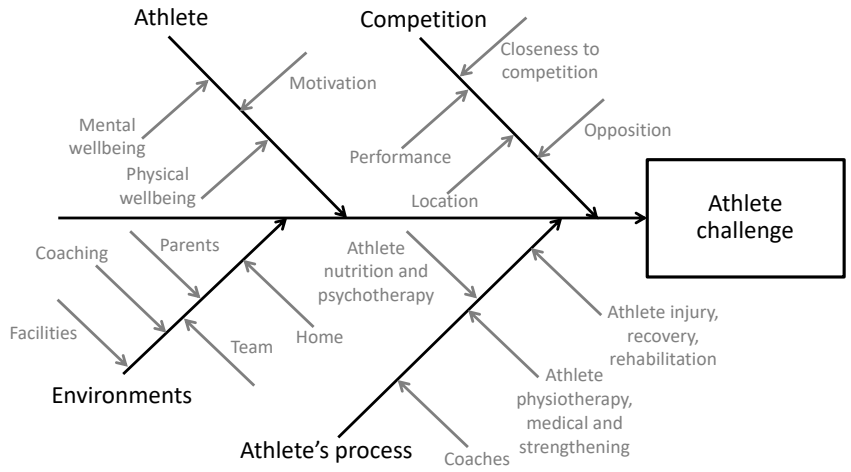

Figure 8. An Ishikawa diagram showing the different rule types used to generate potential ideas to resolve coaching challenges

At run-time, the tool automatically selected five rules to instantiate with one topic randomly selected from the unordered set extracted from the description, and presented these five instantiated rules as what were called *solution sparks* to the coach. The algorithm to generate each set of *solution sparks* is depicted in Figure 9.

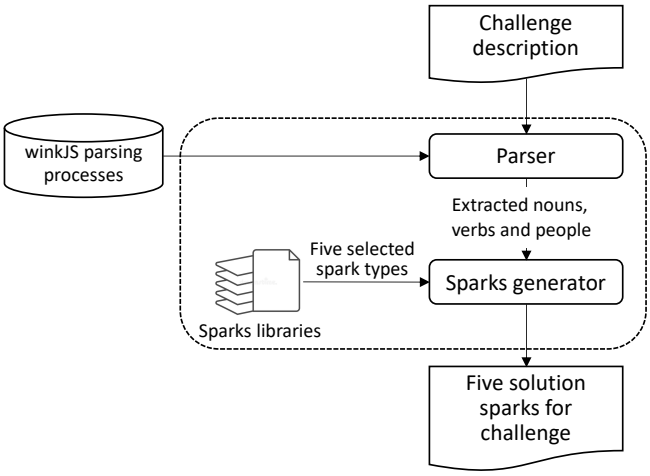

Figure 9. The rule-based reasoning algorithm to generate solution sparks as a means of encouraging exploratory creative thinking by coaches

An example of the guidance to encourage exploratory creative thinking with direction sparks based on entered challenge description in Figure 1 is shown in Figure 10.

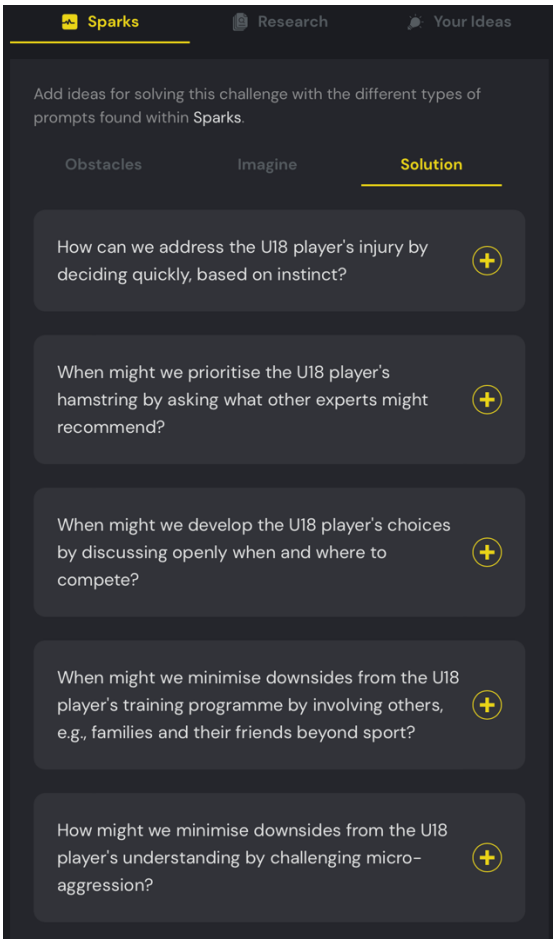

Figure 10. Auto-generated *solution sparks* presented to the coach to encourage exploratory creative thinking

If the coach selected to ideate using one of these *solution sparks*, the tool again opens a pop-up with automatically-generated partial idea expressed in natural language that the coach can edit to complete, see also Figure 11.

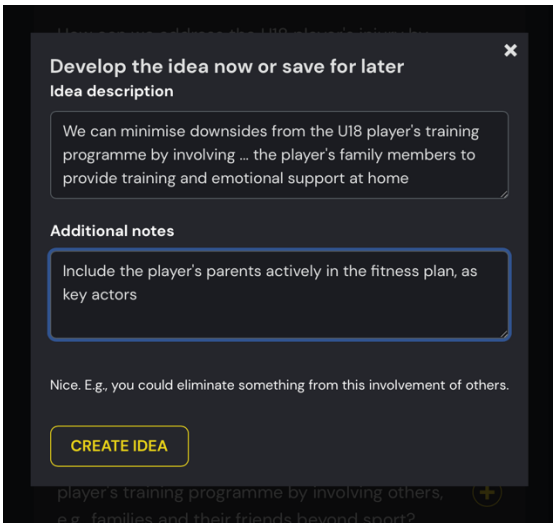

Figure 11. An example of idea generation from one selected *solution spark* as a starting point

3.5 Collaborative creative thinking

The design team proposed features to support synchronous creative collaborations that would enable coaches to brainstorm further and to structure new ideas in real time. However, the sports coaches in the co-design process expressed a clear need for a simpler, more secure and asynchronous collaboration – one that enabled them to share challenges and their ideas to resolve them with trusted colleagues within the *Sport Sparks*™ tool, rather than using public social media channels such as *WhatsApp*. These challenges and ideas might also be shared via email, so the tool was extended with simple features that generated PDFs for the challenges, and copied content to local clipboards to populate MS Word and Excel documents. Therefore, simple features to enable these forms of collaborative creative thinking were implemented in the tool.

3.6 Resolving each sports challenge creatively

To complete the challenge resolution process, *Sport Sparks*™ supported the coach to select between, combine and evolve the ideas generated using the different forms of creative thinking into an action plan for the athlete. Interactive features support the coach to prioritise ideas, generate further new ideas by combining existing ones, and to evolve the ideas to render them operational. Again, different semi-automated support for creative thinking features guided this process. The resulting action plan requested the coach to define the outcome, how the outcome will be identified, who to share the plan with, and dates for its completion.

4 *SPORT SPARKS*™ use and next steps

Previous versions of the *Sport Sparks*™ tool have been evaluated formatively by professional coaches working in six different sports and a leading English Premier League football club. The current version has evolved to be part of a wider service for use at the elite, professional and amateur levels of sports coaching. Planned users of this version of the tool include two national sport coaching organisations, the coaches of both a national rugby union team and another leading English football club, and post-graduate students in strength and conditioning. The service will combine the tool with onboarding activities, training in creative thinking, and expert feedback groups. Evaluations will take place over the summer of 2022. One of our aims is to evolve our research into co-creative AI tools into a full commercial product.

ACKNOWLEDGMENTS

This research is supported by the UKRI's Research England Development fund.

REFERENCES

<bib id="bib1"><number>[1]</number>Abdullah, U., Ligęza, A., & Zafar, K. (2017). Performance evaluation of rule-based expert systems: An example from medical billing domain. Expert Systems, 34:e12218. doi: 10.1111/exsy.12218</bib>
<bib id="bib2"><number>[2]</number>Hossain, M. S., Zander, P.-O., Kamal, M. S., & Chowdhury, L., (2015). Belief-rule-based expert systems for evaluation of e-government: a case study. Expert Systems, 32, 563– 577. doi: 10.1111/exsy.12110</bib>
<bib id="bib3"><number>[3]</number>Hunter G. (2010). Innovation and Creativity – 'Strangled' by Hierarchical Models of Evidence? Reflections from Innovating in Olympic and Paralmypic Sport. Physical Therapy in Sport 11(2), 37-38, doi: https://doi.org/10.1016/j.ptsp.2010.02.001</bib>
<bib id="bib4"><number>[4]</number>Kempf, M., & Memmert, D., (2018). "Good, Better, Creative": The Influence of Creativity on Goal Scoring in Elite Soccer, Journal of Sport Sciences 36(21), 2419-2423. doi: 10.1080/02640414.2018.1459153</bib>
<bib id="bib5"><number>[5]</number>Long, D., Padiyath, A., Teachey, A., & Magerko, B., (2021). The Role of Collaboration, Creativity, and Embodiment in AI Learning Experiences. Proceedings of 12th ACM Creativity & Cognition Conference. ACM Press, Article 28, 1–10. doi: 10.1145/3450741.3465264.</bib>
<bib id="bib6"><number>[6]</number>Maiden, N., Lockerbie, J., Zachos, K. and Wolf, A. (2021). SPORT SPARKS™: Supporting Creative Thinking by Professional Coaches. 9th International Conference on Sport Sciences Research and Technology Support 28-29 October, Online.</bib>
<bib id="bib7"><number>[7]</number>Memmert D. (2007) Can Creativity Be Improved by an Attention-Broadening Training Program? An Exploratory Study Focusing on Team Sports. Creativity Research Journal 19(2-3), 281-291, doi: 10.1080/10400410701397420</bib>
<bib id="bib8"><number>[8]</number>Onarheim B., 2012, 'Creativity under Constraints: Creativity as Balancing 'Constrainedness', PhD Thesis, Copenhagen Business School, December 2012.</bib>
<bib id="bib9"><number>[9]</number>Quinn, S., Bond, R., & Nugent, C., (2017). Ontological modelling and rule-based reasoning for the provision of personalized patient education. Expert Systems, 34: e12134. doi: 10.1111/exsy.12134.</bib>
<bib id="bib10"><number>[10]</number>Rasmussen, L.J.T., Østergaard, L.D., & Glăveanu, P.V., (2019). Creativity as a developmental resource in sport training activities, Sport, Education and Society, 24(5), 491-506. doi: 10.1080/13573322.2017.1403895</bib>
<bib id="bib11"><number>[11]</number>Rice, S.M., Purcell, R., De Silva, S. et al. The Mental Health of Elite Athletes: A Narrative Systematic Review. Sports Med 46, 1333–1353 (2016). https://doi.org/10.1007/s40279-016-0492-2</bib>
<bib id="bib12"><number>[12]</number>Shneiderman, B., (2020). Human-Centered Artificial Intelligence: Three Fresh Ideas. AIS Transactions on Human-Computer Interaction, 12(3), 109-124. doi: 10.17705/1thci.00131 </bib>
<bib id="bib13"><number>[13]</number>Shneiderman, B., (2021). Responsible AI: bridging from ethics to practice. Communications of the ACM, 64(8), 32–35. doi 10.1145/3445973</bib>