ACTIVE METHODOLOGIES IN HIGHER EDUCATION: A SYSTEMATIC MAPPING IN THE CONTEXT OF ENGINEERING COURSES

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ARTIGO

METODOLOGIAS ATIVAS NO ENSINO SUPERIOR: UM MAPEAMENTO SISTEMÁTICO NO CONTEXTO DOS CURSOS DE ENGENHARIA

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RESUMO: As metodologias ativas podem ser entendidas como alternativas pedagógicas que colocam o foco do aprendizado nos estudantes. Com mediação de docentes competentes, os alunos aprendem a partir da descoberta, da investigação e por problemas. Tais metodologias comumente promovem uma maior retenção e compreensão de contéudos ensinados, uma vez que o aprendiz se encontra engajado nas atividades, seja por meio de pesquisa, colaborações em grupo, discussão e resolução de problemas. Este trabalho teve como objetivo verificar a evolução temporal do uso de metodologias ativas, no contexto dos cursos superiores de Engenharia, a partir de um mapeamento sistemático da literatura. A partir de um protocolo de pesquisa devidamente definido, buscou-se verificar quais os principais pesquisadores desta área, sua localização geográfica e quais as metodologias preferidas no contexto destes cursos. A partir dos resultados, foi possível observar que o crescimento do número de publicações científicas sobre metodologias ativas no contexto da Educação em Engenharia, em especial nos últimos cinco anos do período analisado (entre 2015 e 2020). Pode-se notar a realização de pesquisas neste contexto em todos os continentes, com predomínio de estudos liderados por pesquisadores americanos e europeus. Nos estudos mapeados, a sala de aula invertida e a aprendizagem baseada em problemas foram as metodologias mais identificadas. Isso demostra uma maior preocupação dos professores da área em promover atividades com elevado envolvimento, que permitam o desenvolvimento de habilidades e competências pessoais e profissionais, ainda no período de formação.

Palavras-chave: metodologias de ensino; Educação em Engenharia; aprendizagem baseada em projetos; aprendizagem baseada em problemas; sala de aula invertida.

ACTIVE METHODOLOGIES IN HIGHER EDUCATION: A SYSTEMATIC MAPPING IN THE CONTEXT OF ENGINEERING COURSES

ABSTRACT: Active learning is all pedagogical alternatives that place the focus of learning on the students. With the mediation of competent teachers, the students learn by discovery, by investigation, and by problems. Such methodologies commonly promote more content retention and comprehension once the students are engaged in activities, whether through research, group collaborations, discussion, and problem solving. This work aimed to verify the temporal evolution of active learning methods in higher education Engineering courses, based on a systematic mapping of the literature. We observed which are the main researchers in this field, their geographic location and which methodologies are preferred in the context of these courses. From the results, we observe a growth of scientific publications

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on active learning methodologies and Engineering Education, especially in the last five years of the period analysed (between 2015 and 2020). We also see researchs on this field in all continents, with a predominance of studies led by American and European researchers. In the mapped studies, the inverted classroom and problem-based learning were the most identified methodologies. It demonstrates a concern of teachers in this area to promote activities with high involvement, which allow the development of personal and professional skills and competencies, even during their training period.

Keywords: active learning; Engineering Education; Project-Based Learning; Problem-Based Learning; Flipped Classroom.

METODOLOGÍAS ACTIVAS EN LA ENSEÑANZA SUPERIOR: UNA CARTOGRAFÍA SISTEMÁTICA EN EL CONTEXTO DE LOS CURSOS DE INGENIERÍA

RESUMEN: Las metodologías activas pueden entenderse como alternativas pedagógicas que ponen el foco del aprendizaje en los alumnos. Con la mediación de profesores competentes, los alumnos aprenden a partir del descubrimiento, la investigación y los problemas. Estas metodologías suelen promover una mayor retención y comprensión de los contenidos enseñados, ya que el alumno participa en actividades, ya sea a través de la investigación, la colaboración en grupo, el debate y la resolución de problemas. Este trabajo tuvo como objetivo verificar la evolución temporal del uso de las metodologías activas en el contexto de los cursos de educación superior en Ingeniería, a partir de un mapeo sistemático de la literatura. A partir de un protocolo de investigación debidamente definido, se buscó verificar cuáles son los principales investigadores en esta área, su ubicación geográfica y cuáles son las metodologías preferidas en el contexto de estos cursos. A partir de los resultados, se pudo observar que el crecimiento en el número de publicaciones científicas sobre metodologías activas en el contexto de la Enseñanza de la Ingeniería, especialmente en los últimos cinco años del período analizado (entre 2015 y 2020). Se puede observar la realización de investigaciones en este contexto en todos los continentes, con un predominio de estudios dirigidos por investigadores americanos y europeos. En los estudios mapeados, el flipped classroom y el aprendizaje basado en problemas fueron las metodologías más identificadas. Esto demuestra una mayor preocupación entre los profesores de la zona por promover actividades con alta implicación que permitan el desarrollo de habilidades y competencias personales y profesionales durante el periodo de formación.

Palabras clave: metodologías de enseñanza; enseñanza de la ingeniería; aprendizaje basado en proyectos; aprendizaje basado en problemas; aula invertida.

INTRODUÇÃO

As metodologias ativas podem ser entendidas como quaisquer métodos de ensino que envolvam ativamente os estudantes durante o processo de aprendizagem. Por meio de ações e atividades significativas, os alunos tem reflexões sobre o que estão fazendo e o que estão aprendendo. Alternativamente, tais abordagens podem ser indicadas na literatura como ensino indutivo. Tais métodos tem em comum o fato de que o aluno assume uma maior responsabilidade e protagonismo pelo seu aprendizado, que pode estar baseado em pesquisas e/ou atividades colaborativas, envolvendo discussão e solução de problemas. O professor assume uma posição de facilitador da aprendizagem, não atuando como fonte primária do conhecimento, avaliando e observando o progresso de seus estudantes e dando o auxílio necessário, em momentos específicos. Como resultado do engajamento dos discentes, nota-se uma maior retenção e compreensão dos conteúdos abordados, além de uma maior atenção e concentração nas atividades propostas (Prince, 2004; Prince e Felder, 2006; Hernández-de-Menéndez et al.; 2019).

Apesar de serem consideradas recentes e modernas, as metodologias ativas já eram destacadas por autores clássicos na Educação no início do século XX, tais como John Dewey e Lev Vygotsky, no contexto da formação escolar de crianças e jovens. O primeiro salientava a importância de que o conhecimento passado em sala de aula deveria ser sempre introduzido por situações reais, que gerassem interesse dos alunos em aprender, já que a educação deveria ser considerada como um processo de vida e não como um processo de preparação para uma vida futura (Williams, 2017). Já o segundo indicava as atividades interativas, tais como discussões produtivas, feedbacks construtivos e a colaboração com os outros, como fundamentais para a construção do conhecimento, sendo o professor o principal promotor e motivador deste tipo de interação (Kurt, 2020). Ambas as características enfatizadas por estes autores são pilares fundamentais das metodologias ativas aplicadas em tempos atuais.

Mesmo com as diferentes vantagens e os bons resultados do uso de metodologias ativas, a maioria dos professores ainda prefere as metodologias tradicionais, especialmente os professores das áreas de Ciência, Tecnologia, Engenharia e Matemática (comumente agrupadas pela sigla em inglês STEM – Science, Technology, Engineering and Mathematics) (Stains et al. 2018). Os principais motivos alegados pelos professores são tempo insuficiente para preparo das aulas com novas metodologias, recursos limitados, falta de apoio institucional, dificuldade de abordar conteúdos e fazer avaliações usando tais abordagens, resistência dos estudantes em participarem das atividades ativas propostas, em assumirem a responsabilidade pelo seu aprendizado e de serem forçados a realizarem atividades em grupo (Henderson et al., 2007; Felder, 2010; Deslauriers et al., 2019).

Apesar de tais fatos, universidades e docentes, em iniciativas próprias, tem considerado os diferentes benefícios das metodologias ativas e tem investido em ambientes e situações propícias para sua adoção nos currículos do ensino superior (Hernández-de-Menéndez et al.; 2019). A necessidade de formar profissionais com capacidade técnica aliada à capacidade de resolução de problemas, presentes no dia-a-dia das profissões, incentiva o uso dessas abordagens com os estudantes universitários, nas mais diferentes áreas. O desenvolvimento de competências e habilidades valorizadas pelo mercado de trabalho, tais como o pensamento crítico, a análise e resolução de problemas, a liderança, o trabalho em equipe, o uso de tecnologias da informação e da comunicação, dentre outros; também são consequências atraentes ao uso das metodologias ativas (Prince e Felder, 2006).

A pandemia do Covid-19, as ações de distanciamento social e a súbita implantação do ensino remoto também são fatores de influência na utilização de abordagens ativas. Neste contexto, os docentes se viram desafiados a manter um ensino atrativo e qualidade, por meio das telas de computadores, celulares e TVs. O uso de métodos de maior engajamento dos estudantes, em conjunto com ferramentas tecnológicas, apresenta elevado potencial para a manutenção do desempenho e do aprendizado, mesmo em tempos em que os encontros presenciais não foram possíveis (Donitsa-Schimdt e Ramot, 2020; Singhal et al., 2020; Palmeira et al., 2020).

Considerando este contexto, o objetivo geral deste trabalho é verificar a evolução temporal, no Brasil e no mundo, do uso de metodologias ativas no contexto de cursos superiores de Engenharia,

por meio de um mapeamento sistemático da literatura. Especificamente, busca-se identificar os principais pesquisadores envolvidos nas pesquisas desta área nos últimos anos, sua localização geográfica, além de verificar a presença brasileira nestas pesquisas. A partir de uma análise breve dos títulos, resumos e palavras-chave dos trabalhos listados, busca-se identificar qual a metodologia ativa mais utilizada pelos docentes dos cursos superiores de Engenharia. Busca-se assim compreender como tais metodologias tem adentrado as salas de aula destes cursos e como os docentes e discentes tem recebido esta mudança no processo de ensino-aprendizagem.

MATERIAIS E MÉTODOS

O trabalho consiste em um mapeamento sistemático, que de acordo com Kitchenham e Charters (2007), corresponde a um estudo secundário que visa a identificação e classificação de um tema/conteúdo relacionado a um tópico de pesquisa. Seus resultados permitem uma ampla investigação do tema escolhido, possibilitando a averiguação das principais características, conclusões e lacunas da literatura, assim como a sugestão de novos estudos e a utilização de novos métodos, enfoques e/ou abordagens. A realização do mapeamento sistemático demanda a construção de um protocolo de pesquisa, composto de sete etapas básicas (Petersen et al., 2008; Petersen et al., 2015), ilustradas na Figura 1.

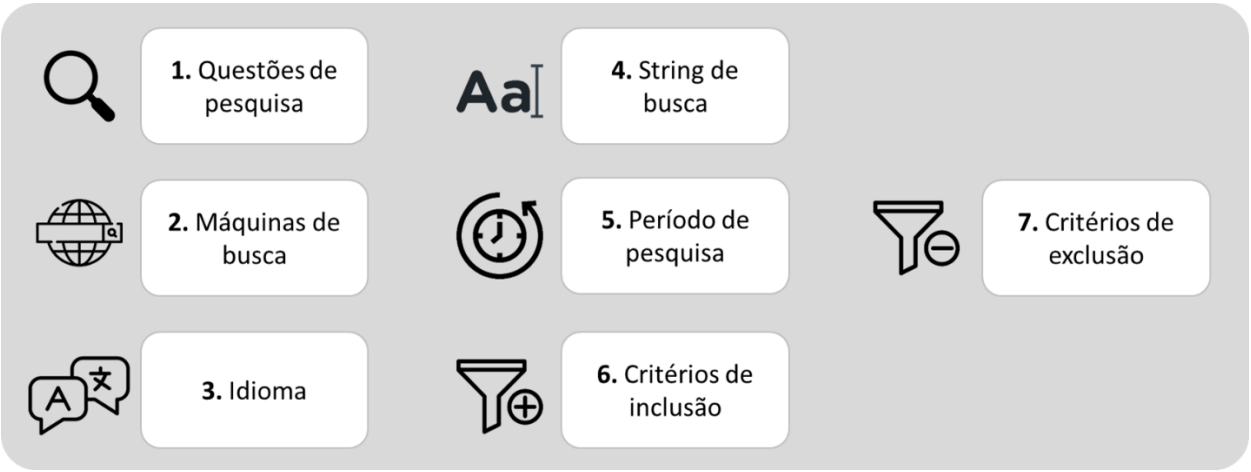


Figura 1 – Sete etapas básicas do protocolo de pesquisa de um mapeamento sistemático (Fonte: Adapatado de Petersen et al., 2015)

Para este trabalho, tais etapas foram assim definidas:

1. Questões de pesquisa: inicialmente, foram definidas 4 questões de pesquisa a serem respondidas neste mapeamento sistemático:

- É possível observar um crescimento do uso de metodologias ativas nos cursos de Engenharia, a partir das publicações encontradas pelo protocolo de pesquisa estabelecido e para o período de estudo selecionado?
- Quais os periódicos são os maiores veículos de divulgação dos trabalhos envolvendo metodologias ativas nos cursos superiores de Engenharia? E quais são os autores e como estes se conectam na produção de tais trabalhos?
- Qual a distribuição geográfica dos pesquisadores que publicaram trabalhos neste período? É possível estabelecer um recorte da presença brasileira nestas pesquisas?
- Ao avaliar os títulos, resumos e palavras-chaves dos trabalhos selecionados, é possível identificar as metodologias ativas mais utilizadas / relatadas pelos pesquisadores?

2. Máquinas de busca: Web of Science (WoS) e ScienceDirect (SciDir). Tais plataformas foram escolhidas por englobarem periódicos que divulgam resultados das áreas de Engenharia.

3. Idioma: Inglês. A escolha deste idioma leva em conta o seu uso majoritário em publicações científicas e a obrigatoriedade de seu uso nas máquinas de busca elencadas.

4. String de busca (ou descritores): ("active learning") AND ("education") AND ("engineering"). Os termos de busca englobam palavras em inglês comumente utilizadas nas publicações que abordam as metodologias ativas e a educação no contexto dos cursos superiores de Engenharia.

5. Período de pesquisa: 2005 a 2020. Acredita-se que o intervalo de quinze anos seja interessante para averiguar as questões de pesquisa estabelecidas. Ao mesmo tempo, será possível estabelecer um cenário prévio a ocorrência da pandemia de Covid-19, que pode ter estimulado o uso de metodologias ativas.

6. Critério de inclusão: serão considerados trabalhos que possuam as strings de busca no título, no resumo e nas palavras-chave.

7. Critério de exclusão: serão considerados apenas trabalhos de pesquisa originais (filtro "Article type - Research articles" no Science Direct e filtro "Document type - Articles" no Web of Science).

Com a aplicação deste protocolo, foi realizada a extração dos dados, que resulta em uma lista de estudos primários. Os dados presentes nesta lista foram sintetizados em gráficos e tabelas, elaborados a partir do uso das seguintes ferramentas computacionais:

- BibExcel (Persson et al., 2009): ferramenta para análises de dados bibliográficos, extraídos das máquinas de busca na forma textual, e que podem ser convertidas em planilhas eletrônicas, para análise quantitativa e geração de gráficos.
- Pajek (de Nooy et al., 2018): ferramenta para geração de redes de colaboração entre autores de artigos, a partir de arquivos gerados na análise com a ferramenta BibExcel.
- GPS Visualizer: ferramenta online para a produção de mapas, a partir de dados de localização dos autores dos estudos listados neste mapeamento sistemático
- WordCloud: ferramenta online para produção de nuvem de palvaras presentes nos títulos, resumos e palavras-chaves dos estudos listados.

Esta síntese de dados buscou encontrar as respostas às questões de pesquisa estabelecidas para este mapeamento sistemático. Tais questões incluem:

- o avanço da presença da temática de metodologias ativas em cursos superiores de Engenharia ao longo dos últimos anos, a partir do número de publicações de artigos científicos, servindo como indicador da implementação de novas abordagens em sala de aula.
- a identificação dos principais veículos de divulgação de tais pesquisas e quais os principais pesquisadores envolvidos, além de sua localização geográfica, a fim de verificar como as pesquisas sobre o tema tem sido divulgadas e tem se espalhado nos diferentes continentes.
- a identificação das metodologias ativas preferidas pelos professores da área de Engenharia, a partir de uma breve análise dos conteúdos básicos dos trabalhos científicos (títulos, resumos e palavras-chave).

RESULTADOS E DISCUSSÃO

A aplicação do protocolo de pesquisa estabelecido resultou na localização de 433 trabalhos de pesquisa originais, sendo 55 resultados obtidos a partir do Science Direct (SciDir) e 378 resultados obtidos no Web of Science (WoS). Foi verificada a existência de 17 repetições de trabalhos, que foram encontrados em ambas as máquinas de busca, os quais foram retirados e considerados uma única vez. Assim, o número final considerado foi de 416 publicações, as quais estão indicadas no Apêndice A (título e ano de publicação).

A distribuição temporal das publicações é apresentada na Figura 2, considerando o período de pesquisa estabelecido, entre 2005 e 2020. Esta figura diferencia os trabalhos encontrados em cada máquina de busca, além de indicar o total acumulado de publicações a cada ano. Os anos com maior número total de trabalhos publicados foram 2019, com 73 publicações (17,5% do total), sendo 69 oriundas do WoS e 4 oriundas do SciDir; e 2020, com 71 publicações (17,1% do total), sendo 57 vindas do WoS e 14 vindas do SciDir.

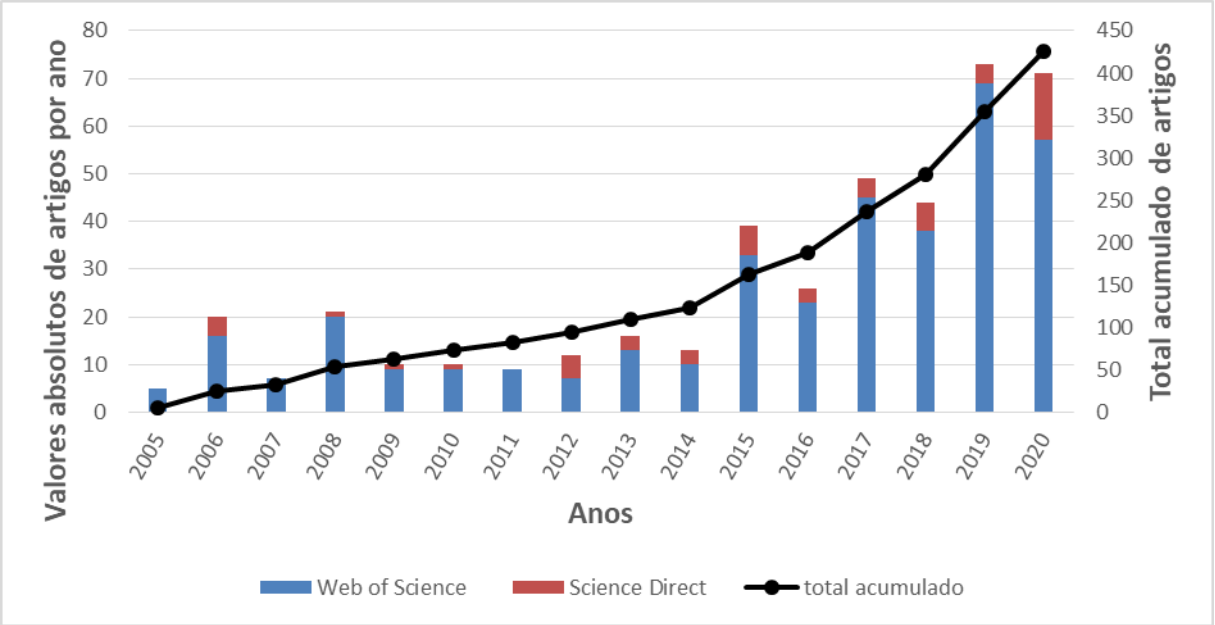


Figura 2. Evolução do número de publicações científicas sobre metodologias ativas em cursos superiores de Engenharia, considerando o protocolo de pesquisa estabelecido (Fonte: Autores, 2022).

É possível observar um aumento expressivo na quantidade de obras publicadas a partir do ano de 2015. Até esse ano, o total de trabalhos divulgados foi de 153, o que equivale a 36,8% das publicações encontradas neste mapeamento. Já entre 2015 e 2020, foram publicados 263 artigos científicos sobre metodologias ativas em cursos superiores de engenharia, correspondente a 63,2% das obras mapeadas e a 1,72 vezes o número de trabalhos identificados entre 2005 e 2015.

Tais resultados são indicativos do crescimento da presença das metodologias ativas nas salas de aula dos cursos superiores de Engenharia, com uma aceleração de seus usos e dos relatos presentes na literatura científica internacional após o ano de 2015 e com picos nos últimos dois anos do período de pesquisa considerado (2019 e 2020). A repetição deste protocolo de pesquisa, em um período posterior, pode ser interessante, a fim de averiguar como o prolongamento da pandemia do Covid-19 pode ter afetado este crescimento, considerando o contexto de isolamento social e de ensino remoto.

Os trabalhos presentes neste mapeamento sistemático foram publicados em 124 periódicos científicos diferentes. A Figura 3 destaca as cinco revistas com maior número de publicações deste mapeamento e a respectiva quantidade de trabalhos veiculados nestes jornais.

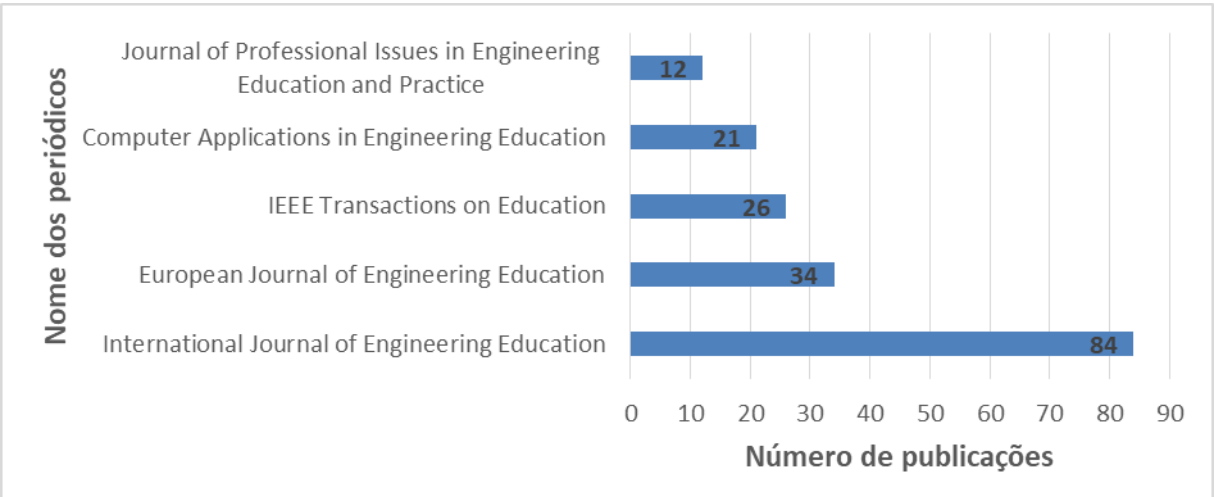


Figura 3. Periódicos com maior número de publicações científicas sobre metodologias ativas em cursos superiores de Engenharia, considerando o protocolo de pesquisa estabelecido. (Fonte: Autores, 2022)

O periódico que apresentou o maior número de trabalhos foi o *International Journal of Engineering Education* (IJEE / ISSN: 0949-149X) com 84 trabalhos, o que corresponde 20,1% das publicações mapeadas. Em seguida, com 34 trabalhos (8,2% do total), observa-se o European Journal of Engineering Education (EJEE / ISSN: 0304-3797). Ambos os periódicos publicam atualmente seis edições por ano e tem em seus escopos a veiculação de pesquisas científicas com foco no desenvolvimento da educação voltada para a Engenharia, em âmbito global e continental.

Os periódicos IEEE Transactions on Education (IEEE ToE / ISSN: 0018-9359) e Computer Applications in Engineering Education (CAE / ISSN: 1061-3773) foram, respectivamente, a terceiro e a quarta revistas com mais publicações neste mapeamento. A IEEE ToE está vinculada ao Instituto de Engenheiros Eletricistas e Eletrônicos (IEEE) e procura veicular pesquisas educacionais ligadas a cursos superiores de Engenharia Elétrica, Eletrônica e de Computação. Tal resultado destaca a presença desta área da Engenharia entre as que mais divulgam seus resultados de metodologias ativas na literatura científica. Já a revista CAE aborda estudos sobre o uso de computadores, Internet, ferramentas e softwares, no contexto da educação de Engenharia, o que também destaca as iniciativas de professores em englobar novas tecnologias, aliadas a metodologias ativas, no contexto de formação dos alunos.

A Figura 4 apresenta os cinco autores mais presentes nos estudos analisados. Este levantamento considerou tanto a posição de autor principal, como de co-autor dos trabalhos. Nos 416 trabalhos analisados, 671 pesquisadores estiveram envolvidos, o que corresponde a uma média de 1,61 pesquisador envolvido por trabalho. Maura Borrego (University of Texas at Austin, EUA) foi a pesquisadora com maior número de trabalhos, com 6 participações, sendo 4 delas como primeira autora. Shane Brown (Oregon State University, EUA) foi o segundo, com 5 participações, sendo 2 como autor principal. Jeffrey Rhoads (University of Purdue, EUA), Noboyuki Ogawa (Gifu National College of Technology, Japão) e José Manuel Lopez-Guede (Universidad del Pais Vasco, Espanha) completam a lista. Um fato interessante e comum a tais pesquisadores é sua formação incial em Engenharia e a realização de estudos posteriores, buscando integrar as metodologias ativas aos cursos que pertencem.

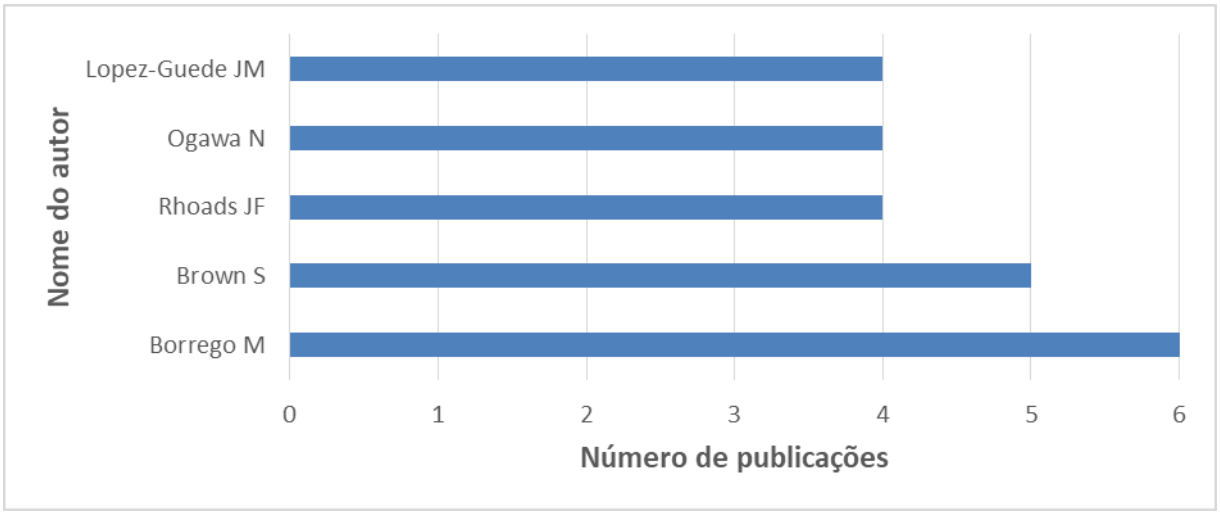


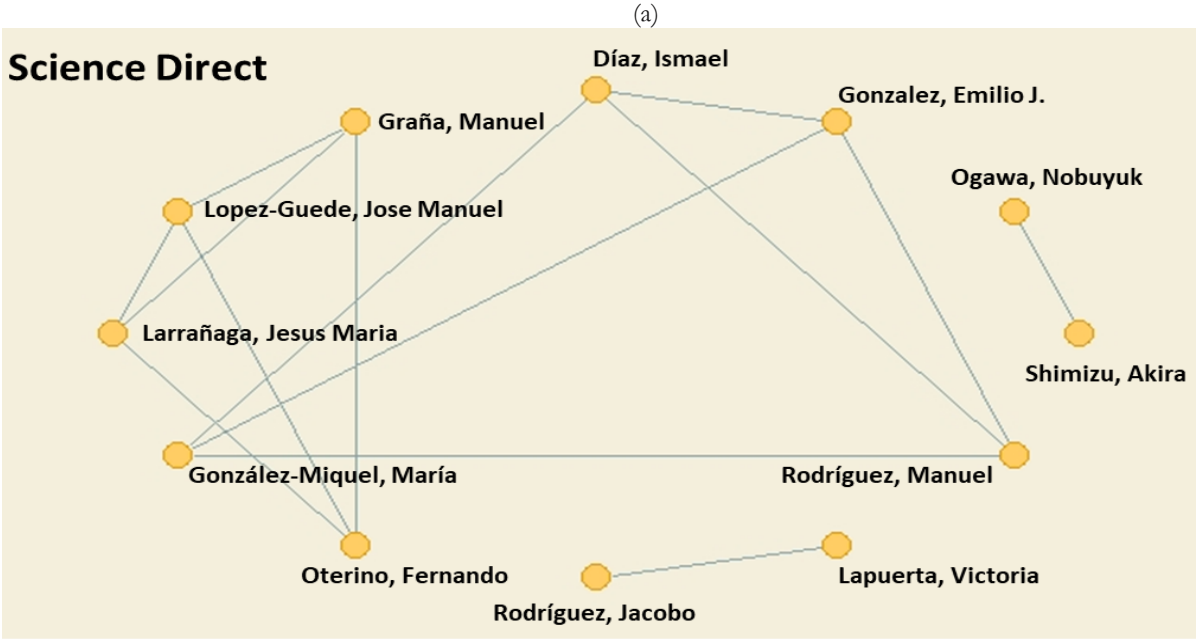
Figura 4. Autores com maior número de participação em trabalhos, considerando o protocolo de pesquisa estabelecido (Fonte: Autores, 2022)

As Figuras 5a e 5b apresentam as redes de conexão entre os autores envolvidos nos estudos listados neste mapeamento, divididos pela máquina de busca (Science Direct e Web of Science, respectivamente). Uma conexão indica que um autor publicou ao menos um trabalho com o outro. Não é possível apresentar todos os 671 pesquisadores envolvidos nestas figuras nem todas as conexões existentes. Desta forma, as conexões mais frequentes são exibidas nas figuras.

É interessante notar que a interação entre tais autores não é intensa, o que indica a realização de estudos mais locais, que relatem experiências em cada universidade ou em cada curso em que estão envolvidos. Mesmo os autores com mais publicações, apresentados na Figura 3, apresentam poucas colaborações. Maura Borrego e Noboyuk Ogawa apresentam uma única colaboração frequente, enquanto José Manuel Lopez-Guede apresenta três conexões frequente, sendo todas de mesma

nacionalidade. Shane Brown e Jeffrey Rhoads não aparecem nestas redes, uma vez que seus trabalhos foram sempre realizados com diferentes profissionais, pouco frequentes na divulgação dos resultados por meio dos artigos.

(a)



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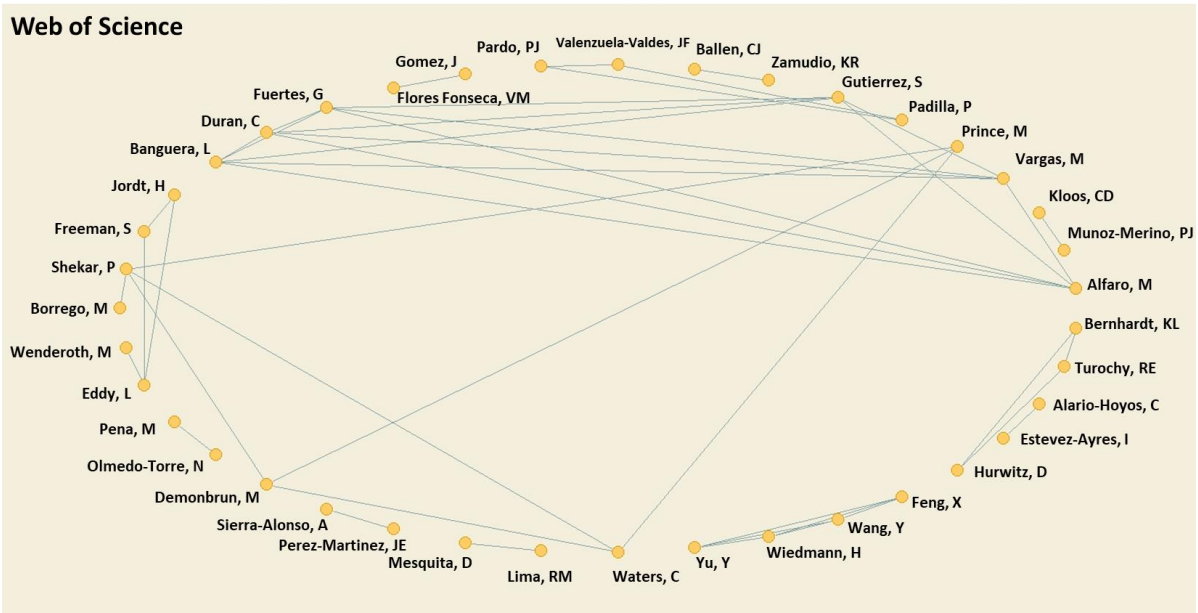
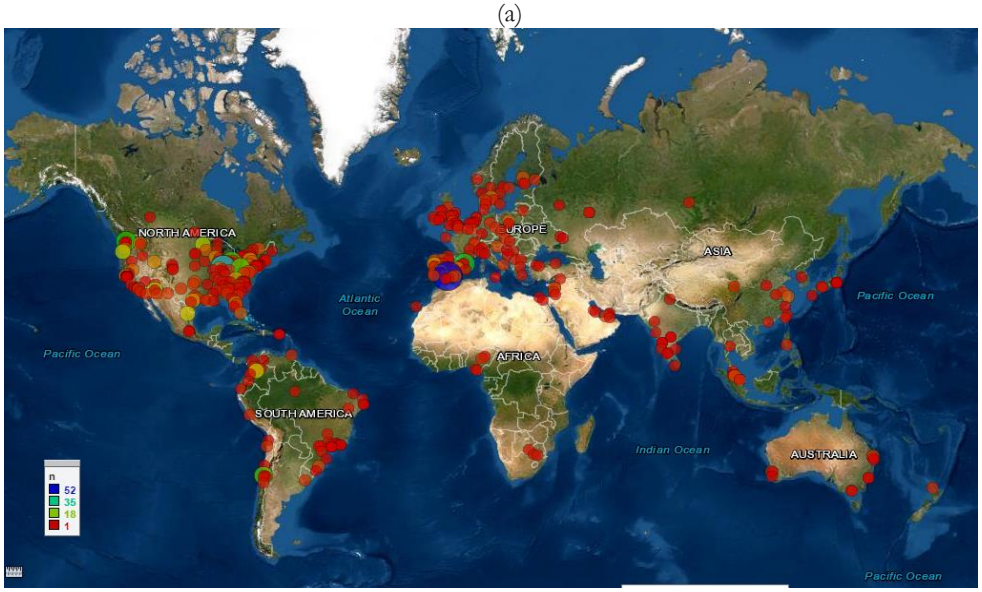


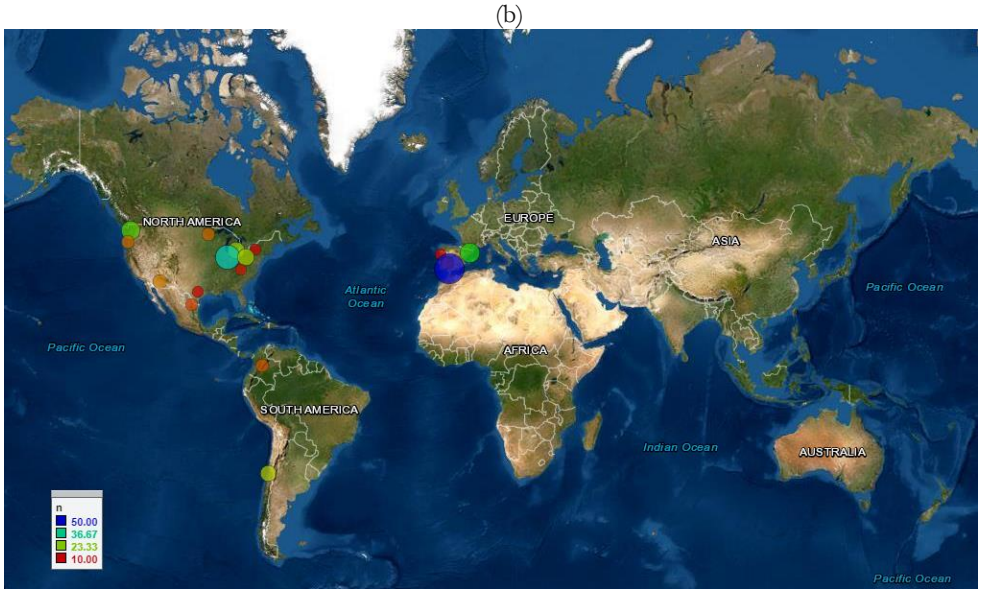
Figura 5. Redes de conexão entre autores participantes dos trabalhos, divididos em função da máquina de busca: (a) Science-Direct e (b) Web of Science. (Fonte: Autores, 2022)

Quando observamos a lista dos autores com mais trabalhos e as redes de conexão mais frequentes, é possível avaliar que há um predomínio de autores americanos e europeus, especialmente espanhóis. Tal avaliação pode ser confirmada na Figura 6, que exibe a localização geográfica dos pesquisadores envolvidos nos trabalhos listados neste mapeamento. Esta avaliação foi realizada apenas para os trabalhos obtidos pela máquina de busca Web of Science, já que os resultados da pesquisa nesta plataforma, em formato textual, forneciam tal informação, enquanto o Science Direct não fornecia.

(a)



(b)



(c)

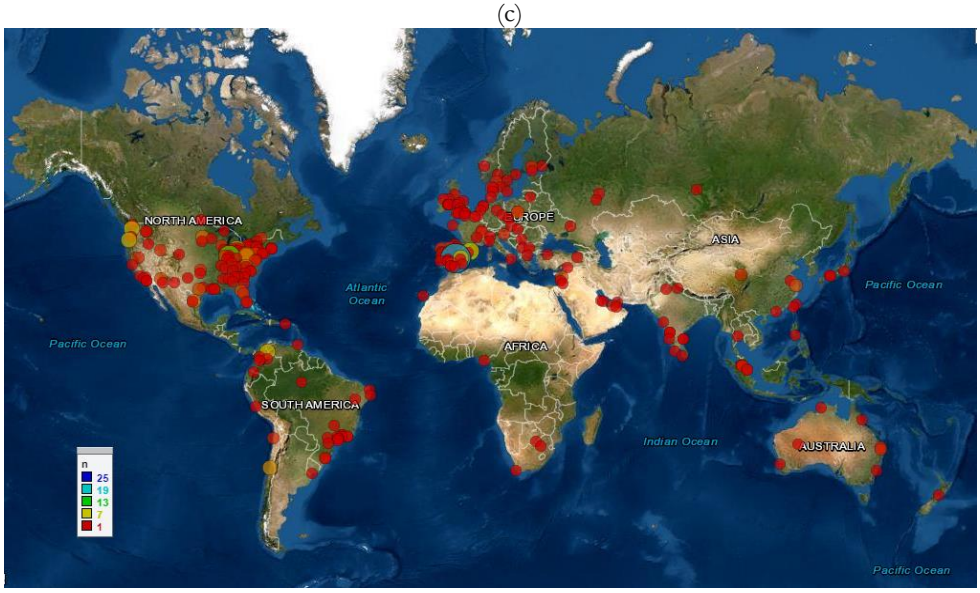


Figura 6. Mapa de localização dos pesquisadores envolvidos nas pesquisas listadas neste mapeamento sistemático, a partir da Web of Science. Tamanho do círculo e cores indicam as quantidades em cada cidade/região. (a) localização de todos os autores envolvidos; (b) localidades que apresentaram 10 ou mais trabalhos; (c) localidades de origem dos primeiros autores. (Fonte: Autores, 2022)

Ao se observar todos os autores (Figura 6a), é possível avaliar o predomínio da nuvem de pontos sobre os Estados Unidos e a Europa. Círculos coloridos e de maior diâmetro indicam as localidades com maior presença dos pesquisadores. Madrid (Espanha), com 59 repetições; West Lafayette (Estados Unidos), com 39 repetições; e Barcelona (Espanha), com 29 repetições são as cidades com mais autores participantes nas pesquisas listadas.

O predomínio americano e europeu sobre os demais continentes fica ainda mais evidente na Figura 6b, que restringe as localidades que apresentaram ao menos 10 repetições. Nesta condição, nota-se a inexistência de pontos na Ásia, Oceania e África, além de uma grande redução na presença de trabalhos oriundos da América do Sul. Nesta última região, destacam-se os trabalhos realizados no Chile e na Colômbia, que em termos de uma mesma localidade, apresentaram mais trabalhos que o Brasil.

Já a Figura 6c exibe a localização dos primeiros autores. O predomínio europeu e americano continua evidente, considerando que tais regiões possuem uma rede de pesquisa sobre o tema e investimentos em ciência já consolidados, fazendo com que se tornem as principais referências internacionais (Reis et at., 2017). A presença de pesquisadores liderando publicações em todos os continentes é um fato animador, no sentido de que as metodologias ativas já estão difundidas mundialmente e de que há uma preocupação dos professores de Engenharia em trazê-las para a sala de aula.

A Figura 7 apresenta um recorte dos mapas para o continente sul-americano, de forma a destacar o Brasil. Ao se comparar o mapa de todos os autores (Figura 7a) e o mapa de primeiros autores (Figura 7b), nota-se bastante semelhança, o que indica que os pesquisadores brasileiros, em diferentes regiões, lideraram pesquisas relativas à metodologias ativas voltadas aos cursos de Engenharia. Numericamente falando, 40 pesquisadores participaram de tais trabalhos, sendo que 17 destes possui um pesquisador brasileiro como primeiro autor. Quatro das cinco regiões brasileiras apresentaram ao menos uma participação em trabalhos sobre metodologias ativas. Apenas a região Centro-Oeste não teve representantes. A maior concentração de trabalhos foi vista nas regiões Sul e Sudeste, havendo trabalhos oriundos tanto das capitais, quanto de cidades do interior. Apesar deste recorte otimista, acredita-se que o Brasil pode ainda evoluir na realização de pesquisas e na implementação de metodologias ativas nos cursos de Engenharia. É importante salientar que o protocolo desta pesquisa levantou apenas trabalhos publicados internacionalmente e que muitos pesquisadores podem optar por divulgar suas pesquisas em âmbito nacional, por meio periódicos e eventos no próprio país, cujos trabalhos não foram captados neste levantamento.

(a) (b)

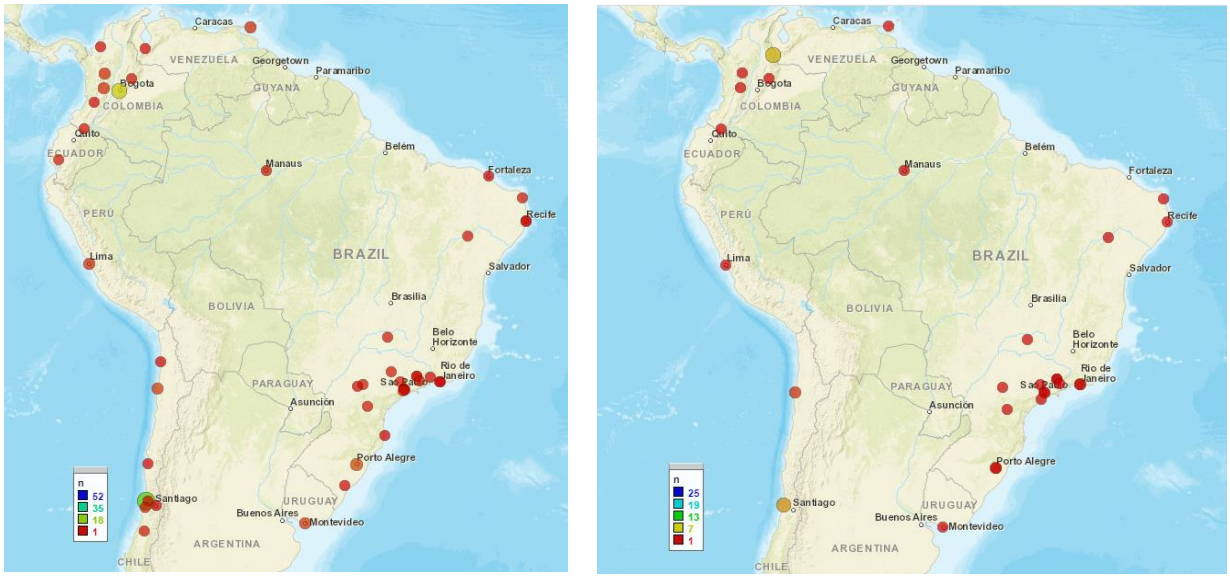


Figura 7. Localização dos pesquisadores brasileiros e sul-americanos envolvidos nas pesquisas listadas neste mapeamento sistemático, a partir da Web of Science. Tamanho do círculo e cores indicam as quantidades em cada cidade/região. (a) localização de todos os autores envolvidos; (b) localidades de origem dos primeiros autores. (Fonte: Autores, 2022)

Por fim, a Figura 8 apresenta três nuvens de palavras obtidas, a partir dos textos dos títulos (Figura 8a), resumos (Figura 8b) e palavras-chave (Figura 8c) dos trabalhos. A montagem destas nuvens de palavras desconsiderou os termos "active learninng"; "education" e "engineering", que foram utilizados como critério de pesquisa dos estudos presentes e inevitavelmente estariam presentes em elevada quantidade nestas nuvens de palavras. Buscou-se aqui verificar os termos com mais repetições e que poderiam ser indicativos das metodologias ativas relatadas pelos autores em cada estudo. Palavras com fontes em maior tamanho são indicativas de maiores repetições.

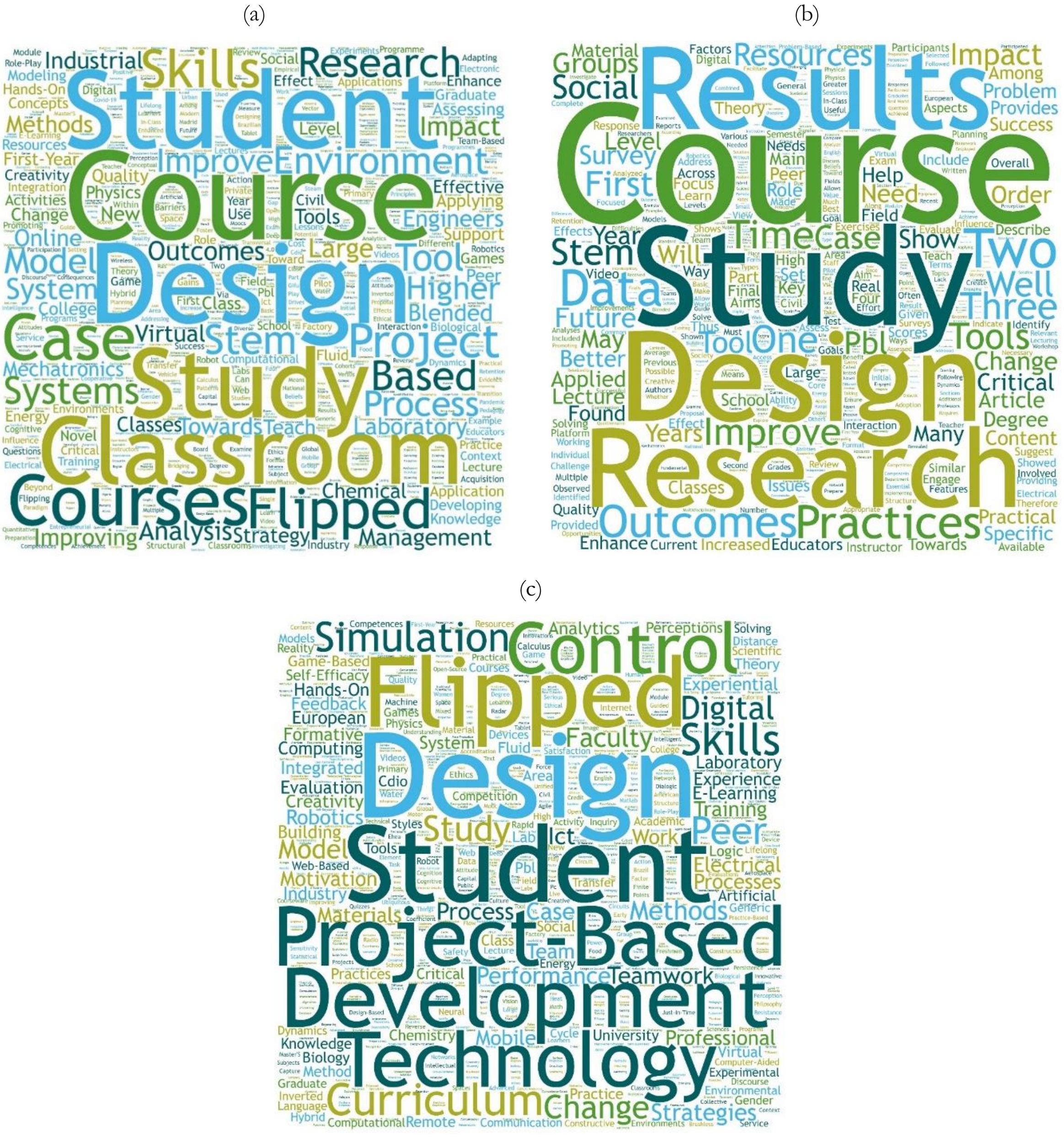


Figura 8. Nuvens de palavras obtidas a partir de (a) títulos; (b) resumos e (c) palavras-chave de todos os trabalhos listados neste mapeamento. Palavras com maiores fontes apresentaram um maior número de repetições. (Fonte: Autores, 2022)

Na análise destes resultados, buscou-se agrupar as palavras em categorias, de forma a elencar motivos indicativos da sua repetição nos textos avaliados. As categorias foram:

- Palavras com muitas repetições e que descrevem elementos da universidade, que inevitavelmente são utilizadas na descrição do ambiente em que as publicações foram realizadas. Destacam-se os termos "student" (estudante); "course(s)" (cursos); "classroom" (sala de aula); "practices" (práticas); "strategies" (estratégias); "curriculum" (currículo); "higher education" (ensino superior);

- Palavras com muitas repetições e que descrevem elementos de trabalhos científicos:palavras comuns da linguagem de artigos científicos, tais como "study" (estudo/trabalho); "research" (pesquisa); "outcomes" (resultados); "results" (resultados, resulta em); "impact" (imapctos); "change" (mudanças); "analysis" (análise); "improving" (melhorias).
- Palavras ligadas à engenharia e à tecnologia: termos como "desgin" (projeto); "development" (desenvolvimento); "technology" (tecnologia); "digital" (digital); "simulation" (simulação); "systems" (sistemas); "tools" (ferramentas); que são palavras comumente presentes no vocabulário dos engenheiros e que podem estar encaixadas nas disciplinas em que as metodologias ativas foram aplicadas.
- Palavras relativas à habilidades e competências desenvolvidas pelos estudantes: podem ter sido utilizadas no sentido de descrever quais os principais resultados esperados e obtidos com a implementação das metodologias ativas. Termos como "skills" (habilidades); "analysis" (capacidade de análise); "management" (capacidade de gerenciamento); "communication" (comunicação); "groups" e "teamwork" (trabalho em grupo); creativity" (criatividade) são as com maior destaque nesta categoria.
- Palavras relativas às metodologias ativas: "flipped" (invertida, que faz menção à sala de aula invertida); 'Project-based" e "PBL" (aprendizagem baseada em problemas e projetos); foram os termos mais repetidos no que se refere às metodologias ativas. Secundariamente, pode-se notar os termos "blended" (ensino híbrido); "peer" (pares, com referência à aprendizagem por pares)" e "case" (caso, em referência a estudos de caso). Tais abordagens podem ser consideradas as mais utilizadas e relatadas pelos autores das publicações listadas neste mapeamento.

Os resultados relativos às metodologias ativas preferidas e mais citadas nos textos coincidem com os visualizados por outros autores em estudos bibliográficos anteriores (Reis et al., 2017; Wankat et al., 2014; Xian e Madhavan, 2014; Jesiek et al., 2011), que apresentaram diferentes protocolos de pesquisa, considerando os termos pesquisados, as máquinas de busca e o período de pesquisa analisado. Neste sentido, nota-se que os professores de Engenharia tem dado preferência ao uso de métodos que facilitem a integração entre a teoria e a prática, uma demanda comum dos estudantes destes cursos, que no ensino tradicional, sofrem com o distanciamento da sala de aula da verdadeira realidade profissional.

As competências e habilidades desenvolvidas com estas metodologias, também identificadas nos termos avaliados, são resultado direto do uso do ensino ativo e contribuem para a formação pessoal e profissional dos estudantes. Além disso, estão em consonância com o novo foco do ensino universitário, onde não só tratar conteúdos técnicos é importante, mas engajar e promover o aprendizado significativo também são fundamentais para o sucesso dos egressos (De los Ríos et al., 2010; Hernández-de-Menéndez et al.; 2019).

CONCLUSÕES

A implementação do protocolo de pesquisa proposto resultou em uma lista de 416 publicações científicas, obtidas a partir das plataformas Science Direct e Web of Science. A análise desta lista permitiu a verificação da distribuição temporal das publicações, o que permitiu observar um forte crescimento na divulgação de trabalhos científicos ligados às metodologias ativas no contexto dos cursos superiores após o ano de 2015. Neste período, 63,2% das obras mapeadas foram publicadas, sendo que os anos de 2019 e 2020 representam juntos 34,6% do total de publicações. Notou-se ainda que 124 periódicos receberam as publicações listadas, sendo que 20,1% delas foram divulgadas pelo International Journal of Engineering Education (IJEE / ISSN: 0949-149X).

O mapeamento dos pesquisadores e da sua localização indicaram a predominância de pesquisas realizadas por americanos e europeus, com destaque para pesquisadores espanhóis. Maura Borrego (University of Texas at Austin, EUA), Shane Brown (Oregon State University, EUA), Jeffrey Rhoads (University of Purdue, EUA), Noboyuki Ogawa (Gifu National College of Technology, Japão) e José Manuel Lopez-Guede (Universidad del Pais Vasco, Espanha) foram os pesquisadores que mais

participaram de publicações no período analisado.Foi possível observar a realização de pesquisas em todos os continentes, o que indica que os professores dos cursos de Engenharia tem se aberto ao uso das metodologias ativas e que as perspectivas futuras podem ser interessantes, no sentido de um favorecimento da aprendizagem nestes cursos. O Brasil também tem participação nas pesquisas internacionais do tema, com 40 pesquisadores como autores e co-autores destas publicações, oriundos de quatro das cinco regiões do país. O predomínio é de pesquisadores localizados no Sul e Sudeste do país, estando tanto em capitais quanto no interior dos estados.

A partir da avaliação dos termos presentes nos títulos, resumos e palavras-chave dos estudos listados neste mapeamento, foi possível observar que as metodologias ativas mais presentes foram a sala de aula invertida, a aprendizagem baseada em problemas e a aprendizagem baseada em projetos. Tais metodologias são facilmente adaptáveis a realidade dos contéudos dos cursos de Engenharia e facilitam a integração entre a teoria e a prática, o que pode motivar os professores a buscarem sua implementação, em um momento de transição entre o ensino tradicional e o ensino ativo.

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CONTRIBUIÇÃO DAS/DOS AUTORES/AS

Autor 1 – Coordenador do projeto, metodologia, coleta de dados, análise dos dados, escrita do rascunho original.
Autor 2 – Supervisão, participação ativa na análise dos dados e revisão da escrita final.
Autor 3 – Administração do projeto, Aquisição de fundos, supervisão, revisão da escrita final.

DECLARAÇÃO DE CONFLITO DE INTERESSE

Os autores declaram que não há conflito de interesse com o presente artigo.

APÊNDICE A – LISTA DE TRABALHOS MAPEADOS

Título	Ano
A Combined Strategy of Additive Manufacturing to Support Multidisciplinary Education in Arts, Biology, and Engineering	2020
Effectiveness of blended instructional design based on active learning in a graphic engineering course	2020
Flipped learning and threshold concepts in the Turbomachinery section of Fluid Engineering course	2020
Improving learner engagement in MOOCs using a learning intervention system: A research study in engineering education	2020
Students' attitude toward sustainability and humanitarian engineering education using project-based and international field learning pedagogies	2020
A computer-aided educational tool for vector control of AC motors in graduate courses	2020
A Flipped Classroom Approach to Teaching Empirical Software Engineering	2020
A Guide to Student-active Online Learning in Engineering	2020
A Project Based Approach for Teaching Product Development to Graduate Students	2020
A Project Based Learning Approach for Teaching Artificial Intelligence to Undergraduate Students	2020
Active Learning Augmented Reality for STEAM Education-A Case Study	2020
Active Learning is About More Than Hands-On: A Mixed-Reality AI System to Support STEM Education	2020
Active learning narrows achievement gaps for underrepresented students in undergraduate science, technology, engineering, and math	2020
Active, experiential and reflective training in civil engineering: evaluation of a project-based learning proposal	2020
An effective blended online teaching and learning strategy during the COVID-19 pandemic	2020
An Exploratory Analysis of the Implementation and Use of an Intelligent Platform for Learning in Primary Education	2020
Applying Multiple Modes of Assessment to Evaluate the Team Work Competence	2020
Assessing evaluation: Why student engages or resists to active learning?	2020
Attaining competencies in Programme Outcomes through Open-Ended Experiments	2020
Barriers and levers driving change in a STEM science subject in the Australian higher education sector: a focused study	2020
BLDC Motor-Driven Fluid Pumping System Design: An Extrapolated Active Learning Case Study for Electrical Machines Classes	2020
Blending Inverted Lectures and Laboratory Experiments to Improve Learning in an Introductory Course in Digital Systems	2020
Challenges of teaching food microbiology in Brazil	2020
Combining the project-based learning methodology and computer simulation to enhance the engagement in the context of Environmental Engineering courses	2020
Developing pre-laboratory videos for enhancing student preparedness	2020
Development of Case-Based Learning (CBL) in Engineering Technology Education	2020
Development of the student course cognitive engagement instrument (SCCEI) for college engineering courses	2020
Digital device-based active learning approach using virtual community classroom during the COVID-19 pandemic	2020
Educational Test Bed 4.0: a teaching tool for Industry 4.0	2020
Effective Pedagogical Strategies for STEM Education from Instructors' Perspective: OER for Educators	2020
Engaging in homework development: TARSIS platform as an innovative learning methodology	2020
Engineering Education for Sustainable Development: Evaluation Criteria for Brazilian Context	2020
Engineering Faculty Members' Perceptions of University Makerspaces: Potential Affordances for Curriculum, Instructional Practices, and Student Learning	2020
How drawing prompts can increase cognitive engagement in an active learning engineering course	2020
Implementing studio-based learning for design education: a study on the perception and challenges of Malaysian undergraduates	2020
Improving performance in a large flipped barrier mathematics course: a longitudinal case study	2020
Initial implementation of active learning strategies in large, lecture STEM courses: lessons learned from a multi-institutional, interdisciplinary STEM faculty development program	2020

Integrated Image-Based Computational Fluid Dynamics Modeling Software as an Instructional Tool	2020
Introducing First-Year Medical Students to Product Innovation and Entrepreneurship	2020
Learning Portfolios and Proactive Learning in Higher Education Pedagogy	2020
Lecture-Free Classroom: Fully Active Learning on Moodle	2020
Motivators and barriers in undergraduate mechanical engineering students' use of learning resources	2020
Multiple Features Fusion Attention Mechanism Enhanced Deep Knowledge Tracing for Student Performance Prediction	2020
Peer-graded individualised student homework in a single-instructor undergraduate engineering course	2020
Revisiting a Measure of Engineering Design Self-Efficacy	2020
Scalable and Practical Teaching Practices Faculty Can Deploy to Increase Retention: A Faculty Cookbook for Increasing Student Success	2020
Self-Efficacy Versus Gender: Project-Based Active Learning Techniques in Biomedical Engineering Introductory Computer Programming Courses	2020
Social-Driven Propagation of Active Learning and Associated Scholarship Activity in Engineering: A Case Study	2020
Staff perceptions of implementing project-based learning in engineering education	2020
Student Perspective on Technology Enabled/Enhanced Active Learning in Educational: Rasch Measurement Model	2020
Student Perspectives on the Learning Resources in an Active, Blended and Collaborative (ABC) Pedagogical Environment	2020
Sustainability coursework: student perspectives and reflections on design thinking	2020
Sustainable and Flipped STEM Education: Formative Assessment Online Interface for Observing Pre-Service Teachers' Performance and Motivation	2020
The Development of Social Capital in an Active, Blended, and Collaborative Engineering Class	2020
The effectiveness of computer-based simulations for numerical methods in engineering	2020
The role of structures in architecture: the multidisciplinary experience of active learning in a master of science	2020
Using videos to improve oral presentation skills in distance learning engineering master's degrees	2020
Developing rigor with Critical Discourse Analysis to examine educators' transition toward active learning	2020
A Novel Framework for Active Learning in Engineering Education Mapped to Course Outcomes	2020
Application of escape lab-room to heat transfer evaluation for chemical engineers	2020
Active learning in control education: a pocket-size PI(D) setup	2020
Challenge-Based Learning in Aerospace Engineering Education: The ESA Concurrent Engineering Challenge at the Technical University of Madrid	2020
A serious game for teaching the fundamentals of ISO/IEC/IEEE 29148 systems and software engineering – Lifecycle processes – Requirements engineering at undergraduate level	2020
Development of educational contents on circular economy and critical raw materials challenges	2020
She Space: A multi-disciplinary, project-based learning program for high school girls	2020
A collaborative working model for enhancing the learning process of science & engineering students	2020
Active Learning Classes (in KOSEN Colleges of Japan) Using ICT and Tools for Obtaining Biological Information to Enhance the Creativity of Engineering Design Students	2020
Introduction to systems engineering and sustainability PART I: Student-centred learning for chemical and biological engineers	2020
A "learning small enterprise" networked with a FabLab: An academic course 4.0 in instrumentation and measurement	2020
Redefining Quality in Engineering Education through the Flipped Classroom Model	2020
Grounded Idea Generation: An Analysis Framework for Project-Based Courses	2020
A learning analytics tool for the support of the flipped classroom	2019
A learning-Centered Paradigm for Engineering Graphics and Design: Engineering Technology Students' Skill Gains and Capstone Preparation	2019
A Peer Review System for BIM Learning	2019
A Reverse Engineering Role-Play to Teach Systems Engineering Methods	2019
A third approach beyond the false dichotomy between teacher- and student-centred approaches in the engineering classroom	2019

Action research: a methodology for transformative learning for a professor and his students in an engineering classroom	2019
Active learning for the promotion of students' creativity and critical thinking An experience in structural courses for architecture	2019
Active Learning via Problem-Based Collaborative Games in a Large Mathematics University Course in Hong Kong	2019
Active Teaching and Learning as a Remedy for Engineering Education Problems	2019
Adapting team-based learning for application in telecommunications engineering using software-defined radio	2019
An interactive computational strategy for teaching the analysis of silo structures in civil engineering	2019
Antecedents of student retention: the influence of innovation and quality of teaching in Brazilian universities	2019
Best teaching practices in the first year of the pilot implementation of the project DrIVE-MATH	2019
CDIO Project Approach to Design Polynesian Canoes by First-Year Engineering Students	2019
Changing an Engineering Curriculum through a Co-Construction Process: A Case Study	2019
Collaborative PBL to Teach Calculus to Engineering Students: The Important Role of Collaborative Professors	2019
Comparison of Engineering Skills with IR 4.0 Skills	2019
Cooperative Learning and Embedded Active Learning Methodologies (R) for Improving Students' Motivation and Academic Results	2019
Despite Similar Perceptions and Attitudes, Postbaccalaureate Students Outperform in Introductory Biology and Chemistry Courses	2019
Development and Implementation of Design-Based Learning Opportunities for Students To Apply Electrochemical Principles in a Designette	2019
Didactic games as student-friendly tools for learning hydraulics in a technical university's undergraduate curriculum	2019
Educational Effect of Participation in Robot Competition on Experience-Based Learning	2019
Effects of the flipped classroom instructional strategy on students' learning outcomes: a meta-analysis	2019
Empowering Engineering Students in Ethical Risk Management: An Experimental Study	2019
Enhancing Railway Engineering Student Engagement Using Interactive Technology Embedded with Infotainment	2019
Enhancing students' written production in English through flipped lessons and simulations	2019
Examining Project Based Entrepreneurship and Engineering Design Course Professional Skills Outcomes	2019
Examining the impact of four teaching development programmes for engineering teaching assistants	2019
Experiences on the Design, Creation, and Analysis of Multimedia Content to Promote Active Learning	2019
ezCADD: A Rapid 2D/3D Visualization-Enabled Web Modeling Environment for Democratizing Computer-Aided Drug Design	2019
Flipped classroomcomparative case study in engineering higher education	2019
Flipped Learning in Engineering Education	2019
Gamified experimental physics classes: a promising active learning methodology for higher education	2019
Impact of implementing a long-term STEM-based active learning course on students' motivation	2019
Impact of Mobile Learning in the Cloud on Learning Competencies of Engineering Students	2019
Impactful engineering education through sustainable energy collaborations with public and private entities	2019
Implementation and Comparative Analysis of Mobile Phone Application for Learning and Teaching in Mechanical Engineering Education	2019
Implementing Student-Created Video in Engineering: An Active Learning Approach for Exam Preparedness	2019
Independent learning as class preparation to foster student-centred learning in first-year engineering students	2019
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