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HENRIQUE MARQUES DAGOSTIN

METODOLOGIAS ATIVAS DE ENSINO E APRENDIZAGEM EM ANATOMIA: UMA REVISÃO SISTEMÁTICA

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Trabalho de conclusão de curso apresentado a Universidade Federal Rural do Semi-Árido como requisito para obtenção do título de Bacharel em Medicina.

Orientador: Maiara de Moraes, Prof. Dra.

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Relatório final, apresentado a Universidade Federal Rural do Semi-Árido, como parte das exigências para a obtenção do título de Bacharel em Medicina.

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RESUMO

A educação tradicional da anatomia foi gradualmente substituída por uma série de abordagens ativas de aprendizagem que favorecem o desenvolvimento de competências relacionadas ao conhecimento, habilidades e atitudes. Este estudo teve como objetivo identificar, sintetizar e demonstrar o uso e implementação das principais abordagens ativas utilizadas no ensino da anatomia humana, destacando suas potencialidades e fragilidades. Identificamos estudos empíricos discutindo o uso de modalidades de aprendizado ativas no ensino de anatomia humana por meio de uma pesquisa no PubMed. Dois pesquisadores avaliaram independentemente a elegibilidade dos estudos pelo título, resumo e revisão em texto completo. A tabulação de dados e análise narrativa dos resultados do estudo foi realizada. Foram selecionados 45 artigos completos que atendiam aos critérios de inclusão da revisão. Foram identificadas vinte e uma abordagens de aprendizado ativo. A sala de aula invertida e a aprendizagem em equipe foram as principais. As abordagens ativas promovem ganho em competências atitudinais, na autonomia e na motivação dos alunos. Por outro lado, metodologias ativas de aprendizagem exigem maior planejamento estratégico do professor e contínuo feedback para os alunos.

Palavras-chave: Aprendizado ativo; Anatomia; Estudantes; Educação; Métodos de ensino.

ABSTRACT

Anatomy traditional education has been gradually replaced by a range of active learning approaches that favor the development of competences relation to knowledge, skills and attitudes. This study aimed to identify, synthesize and demonstrate the use and implementation of the main active approaches used in human anatomy, highlighting their potentialities and weaknesses. We identified empirical studies discussing the use of learning modalities active in the teaching of human anatomy via PubMed search. Two researchers independently assessed the eligibility of the studies by title, abstract, full-text review. Data tabulation and narrative analysis of study findings was performed. We screened 45 full-text articles met criteria for inclusion in the review. A total of twenty one active learning approaches were identified. Flipped classroom and team-based learning were the most utilized approaches. Active approaches promote gains in student attitudinal competencies, autonomy and motivation. On the other hand, active learning methodologies demand more strategic planning by the teacher and feedback to students..

Keywords: Active learning; Anatomy; Students; Education; Teaching/methods.

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1 INTRODUÇÃO

Desde o surgimento das primeiras universidades médicas, o método tradicional centrado no professor tem sido predominantemente empregado. A partir do século XX, começou a ser questionada uma reforma dos currículos médicos, a fim de acompanhar as mudanças socioeconômicas e tecnológicas ocorridas na sociedade. Em 1900, o relatório de Abraham Flexner "Educação médica nos Estados Unidos e no Canadá" reafirmou a metodologia tradicional centrada na doença, de maneira individual e concreta. Em 1984, a Associação Americana de Faculdades de Medicina discutiu novamente esse problema publicando dois relatórios sobre a reforma curricular, demonstrando o crescente uso de metodologias ativas e a aprendizagem baseada em problemas[1]. Isso colocou a América do Norte como o berço das metodologias ativas de ensino[2]. Embora a necessidade de mudanças na educação médica tenha sido um tema importante nos dias de hoje, poucas discussões ocorreram até o final do século XIX.

O ensino tradicional de anatomia por meio de palestras e dissecações foi substituído por módulos que compreendem aprendizagem baseada em problemas (PBL – do inglês *Problem Based Learning*), modelos de plástico ou computador e integração curricular[3]. No entanto, essas novas abordagens devem ser cuidadosamente consideradas, pois, embora sejam eficazes no ensino de anatomia, devem ser avaliadas quanto à eficácia em tornar o processo de aprendizagem construtivo para os alunos[4]. Nenhuma metodologia é absolutamente superior à outra. Algumas escolas, como Harvard, tentam tirar o máximo proveito dos diferentes métodos de ensino, integrando-os[5], englobando diferentes abordagens ativas e o menor número possível de aulas tradicionais[6]. Nesse contexto, o objetivo deste artigo é revisar sistematicamente a literatura sobre o uso, efetividade, pontos fortes e fracos das principais metodologias ativas utilizadas no ensino de anatomia humana nos últimos anos.

2 MATERIAIS E MÉTODOS

2.1 Estratégia da pesquisa

Uma pesquisa bibliográfica abrangente foi realizada por um dos autores (Dagostin). O banco de dados pesquisado foi o PubMed. Os termos de pesquisa incluíram termos de índice (termos MeSH) e palavras em texto livre: "aprendizado ativo" e "anatomia". As pesquisas foram limitadas aos campos de filtros em inglês e nos campos “Título / resumo” (filtros) publicados em periódicos entre 2000 e 2019. No geral, os autores consideraram um limite de 20 anos adequado para garantir que os dados avaliados fossem aplicáveis na educação da graduação em medicina hoje.

2.2 Seleção dos estudos

Todos os artigos utilizados foram selecionados para revisão em texto completo se fossem artigos de pesquisa originais que avaliaram o uso do aprendizado ativo em anatomia humana. A aprendizagem ativa foi definida de acordo com Bonwell e Eison[7] como qualquer método instrucional que envolva os alunos no processo de aprendizagem, de acordo com esses autores “atividades instrucionais que envolvem os alunos em fazer as coisas e pensar no que estão fazendo”[7]. Os revisores emparelhados (Dagostin e Moraes) examinaram títulos e resumos de artigos da busca inicial de forma independente. Citações com resumos que pareciam potencialmente relevantes para os critérios de seleção foram incluídas como candidatas à triagem de texto completo. Os mesmos dois revisores examinaram esses artigos de texto completo independentemente e em duplicata, com base nos critérios de seleção. Editoriais, comentários, autobiografias, cartas, pesquisas e resenhas foram excluídos. Quando surgiu uma discrepância na seleção de artigos entre os dois revisores na etapa de triagem de texto completo, o desacordo foi arbitrado por um terceiro revisor (Silva) que atuou como desempate.

2.3 Extração dos dados

A revisão sistemática foi orientada pelos itens do relatório preferencial para revisões sistemáticas e declaração de meta-análise (PRISMA)[8]. Uma estrutura de extração padrão foi desenvolvida para abstrair e codificar dados dos estudos selecionados. Os dois autores (Dagostin e Moraes) leram cada artigo independentemente e usaram a estrutura de extração para extrair

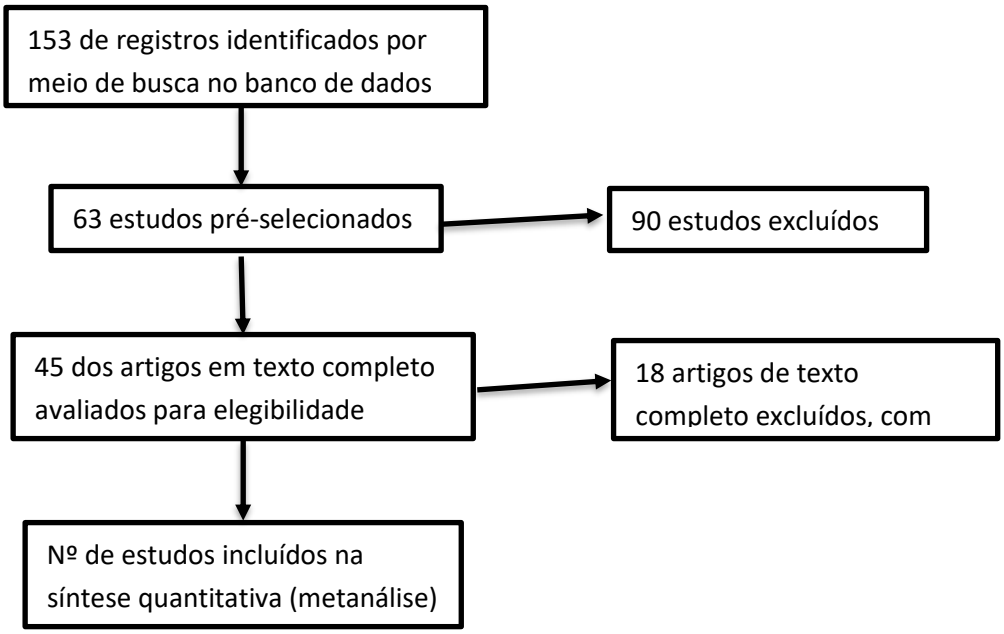
dados. Os dados extraídos foram o país em que o estudo ocorreu, tipo de curso, tipo de sistema anatômico, tipo de aprendizado ativo (aprendizado em equipe, aprendizado baseado em problemas etc.) e as potencialidades e fraquezas do aprendizado ativo em avaliação. Esta informação pode ser encontrada no anexo 1.

3. RESULTADOS E DISCUSSÃO

3.1 Estudos selecionados

Cento e cinquenta e três artigos potencialmente elegíveis foram identificados no banco de dados PubMed. Outros 107 artigos foram excluídos após a seleção do título e / ou resumo, deixando 45 para revisão em texto completo. Os artigos excluídos apresentaram temas diferentes do escolhido em nosso estudo, como radiologia, neurologia, histologia, entre outros, ou não discutiram abordagens ativas no ensino da anatomia humana. A seleção final das publicações identificadas no banco de dados PUBMED resultou em 45 artigos que atenderam aos critérios de inclusão estabelecidos anteriormente e foram submetidos à análise exploratória e descritiva dos dados (Tabela 1). Mais detalhes mostrados no fluxograma PRISMA (Figura 1).

Figura 1 – Fluxograma PRISMA



3.2 Características dos estudos sobre metodologias de ensino incluídos

Esta revisão sistemática examinou o papel da aprendizagem ativa da anatomia humana na graduação. Revelou um grande número de variações nas abordagens de aprendizagem ativa. Devido à heterogeneidade desses estudos, foi difícil avaliar a eficácia e utilidade geral dessas abordagens de aprendizagem para a anatomia humana. Apesar disso, os resultados gerais foram positivos e as abordagens avaliadas estão descritas abaixo.

3.2.1 Laboratório de Aprendizado Ativo

O laboratório de anatomia fornece um ambiente ideal para a utilização de métodos ativos. Um estudo descreveu o uso de quatro estações, as duas primeiras sendo compostas por um esqueleto articulado de plástico sobre uma mesa, um atlas e suplementos (espuma, tubos etc.) para representar músculos, vasos e nervos. Os alunos deveriam construir um modelo de triângulo femoral (estação 1) e a região ao redor da fossa supraclavicular (estação 2). Na estação 3 foram fornecidas esqueleto plástico e imagens radiológicas do ombro e da pelve. Nesta estação, os alunos combinaram as estruturas marcadas nas imagens com as estruturas marcadas no esqueleto, nomeando as estruturas. Na última estação, um operador de ultrassom orientou os alunos, mostrando as características das imagens no pescoço e nos membros superiores, e os próprios alunos se revezaram atuando como pacientes nessa estação. Depois de passar por todas as estações, a turma discutiu o conteúdo[9].

3.2.2 Pintura Corporal

A pintura corporal foi realizada para o ensino da anatomia da mão[10], face, sistema respiratório, músculo esquelético, cabeça e pescoço[11]. Cada aluno teve 20 minutos para pintar a mão, 20 minutos para pintar a mão do outro aluno e mais 20 minutos para discussão, em comparação outros estudantes participaram de uma aula tradicional apenas, por 1 hora. No teste realizado imediatamente após e um mês depois os alunos não apresentaram diferenças significativas na pontuação total, mas em questões específicas sobre a superfície pintada os os alunos do grupo controle tiveram o melhor desempenho[10].

3.2.3 Aprendizagem Baseada em Casos

A aprendizagem baseada em casos utiliza casos de pacientes para incentivar discussões, questionamentos, resolução de problemas e raciocínio sobre assuntos relacionados às ciências básicas e clínicas[12]. Possui diversas aplicações, como o desenvolvimento teórico pelo instrutor de anatomia relevante para o caso, a apresentação de casos aos alunos, desencadeando discussões em pequenos grupos e debates com toda a turma, a fim de responder a perguntas previamente entregues[13]. A introdução da entrevista clínica, histórico de medicamentos, exames de imagem e laboratoriais e achados em exames físicos reais em pacientes são outras maneiras de usar o

aprendizado baseado em casos, bem como discutir o caso e as perguntas respondidas em pequenos grupos com a ajuda do professor[12].

3.2.4 Lista de Verificação

É usado para orientar estrategicamente os estudos anatômicos dos alunos, pois garante que as principais estruturas serão abordadas. A lista de verificação (*check list*) pode ser impressa a qualquer momento durante a aula, porque, de acordo com os alunos, é melhor do que recebê-la por e-mail. Também pode ser escrito no quadro branco do laboratório[14].

3.2.5 Clickers

Os sistemas de resposta pessoal, também conhecidos como *clickers*, são equipamentos semelhantes a um controle remoto. Cada aluno clica na parte inferior para escolher uma resposta rápida às perguntas do professor projetadas nos slides. O estudo avaliado foi baseado em discussões em grupo e em decisões coletivas substanciadas pelas respostas dadas[15]. Os *clickers* podem ser associados a outras abordagens ativas, como a aprendizagem baseada em equipe (TBL). Essa prática favorece a coleta de respostas individuais e em grupo, e fornece feedback imediato para discussões em grupo, fato considerado essencial para um aprendizado significativo.

3.2.6 Construção de Modelos Físicos

Os alunos montaram um esquema do músculo esquelético com base no Método Socrático, usando cordões de cores diferentes, cordão de miçangas, tubos de papel e papel de alumínio - cada material representa os componentes dos miofilamentos[16]. Este modelo enfatiza a partição e os aspectos biomecânicos do acoplamento excitação-contração no nível dos sarcômeros, mas não aborda outros aspectos dele. Para ter uma alternativa a esse obstáculo, a idéia é adicionar animações e / ou simulações em computador; além disso, pede-se aos alunos que alterem criativamente o modelo para abordar esses outros aspectos.

3.2.7 Desenho

O aprendizado baseado em desenho pode ser aplicado ao aprendizado de anatomia como um todo; seu uso é ilimitado[17]. Um experimento, com base no qual os alunos desenham os corpos

na frente deles, foi descrito. Eles desenhavam os corpos em vez de dissecá-los, isso foi feito para destacar as limitações das imagens impressas e digitais do corpo[18]. Outro experimento foi baseado na geração de um diagrama / figura, rotulando a função das estruturas, bem como a ação dos medicamentos e hormônios usados, e a solução de problemas ou respostas dadas a uma pergunta (em pares ou em grupo) - todo o processo terminou com uma discussão aberta[19]. Outro relatório dizia respeito ao uso de um rascunho anatômico junto com a projeção de desenhos[17]. O cérebro está envolvido ativamente na análise da direção e posição apropriada das estruturas anatômicas quando o indivíduo as desenha[19]; portanto, esse processo contribui para o aprendizado dos alunos.

3.2.8 Aprendizagem Online

A técnica de E-learning, ou aprendizagem online, permite infinitas possibilidades de aprendizado para os alunos. Identificou-se o uso de vídeos instrutivos aplicados como diretrizes, este procedimento foi baseado na adoção de partes idênticas às disponíveis para os alunos no laboratório - indica estruturas específicas para orientar os objetivos de aprendizagem[20]. Outra abordagem foi baseada em um workshop sobre anatomia dependente de assistência informática. Essas aulas visavam ajudar os alunos a entender melhor as imagens médicas digitais e melhorar sua capacidade de navegar pelas imagens de computador. O software Virtual Human Dissector (VHD) e o site de acesso gratuito Human Anatomy Online foram as principais ferramentas de ensino deste módulo de ensino[21]. Um terceiro estudo passou 7 das 30 horas programadas para a disciplina para o workshop em atividades on-line realizadas no software Sistema Integrado de Aprendizagem, Informação e Cooperação no Trabalho (ILIAS®). Essas atividades foram divididas em três etapas, a saber: exercícios para preencher os espaços em branco, um vídeo online sobre anatomia humana e outro com exemplos clínicos, e um teste relacionado aos vídeos[22].

3.2.9 Sala de Aula Invertida

O objetivo principal de uma sala de aula invertida é estabelecer um ambiente de aprendizado focado no aluno, baseado no aprendizado ativo e colaborativo[23]. As práticas tradicionais aplicadas em ambientes de sala de aula são realizadas em casa (antes da aula), e as tarefas frequentemente realizadas em casa são concluídas durante o horário de aula. Os estudos a serem avaliados são enviados uma semana antes e o material de apoio (a folha com as perguntas a serem respondidas) deve ser respondido e devolvido antes da aula[24,25]. Outro estudo foi baseado na aplicação de um teste antes da aula[23], ou mesmo no uso de diretrizes de leitura com perguntas

para avaliar o entendimento dos alunos sobre suas leituras[26]. Essas abordagens permitem avaliar a preparação das aulas, uma vez que o método depende desse estágio para ser bem-sucedido. O uso combinado de tecnologias digitais tem mostrado resultados promissores[23,25,27], e os alunos que adotaram essa abordagem conseguiram responder com mais precisão a questões sobre a alta complexidade da Taxonomia Bloom (aplicação e análise)[28]. Entretanto, muitos autores enfatizam a necessidade de uma análise cuidadosa da carga de trabalho necessária para os alunos, equilibrando o material pré-aula, bem como estabelecendo metas claras de aprendizado e os resultados esperados[23,25,26,27,29].

3.2.10 Aprendizagem Baseada em Jogos

Existem inúmeros jogos que podem ser usados ou adaptados ao ensino de anatomia. Foi relatada a adaptação do jogo de tabuleiro denominado Funglish, que possui cartas descritivas com substantivos. O novo jogo foi chamado ClueConnect, suas cartas descritivas foram substituídas por cartas com adjetivos e verbos sobre anatomia. As categorias incluíram direções anatômicas (superior ou distal, por exemplo), tipo de tecido (epitelial ou secretório, por exemplo), qualidade (elástica ou oca, por exemplo) e ações (comunicação ou articulação, por exemplo)[30]. Houve outro estudo[31] cujos alunos incorporaram um perfil muscular; eles se apresentaram aos colegas usando o nome do músculo, sua origem, inserção e ação. Eles tiveram que mostrar um exercício funcional desse músculo e os outros alunos tiveram que encontrar seu par (antagônico ao músculo primário). Os testes foram realizados no software Anatesse 2.0, que possui animações, suporte ao capítulo e testes do tipo quiz de auto-estudo para serem respondidos em grupo[32].

3.2.11 Modelos Vivos

Atores vestindo roupas grandes e chinelos foram usados para identificar facilmente características anatômicas em seus corpos[33]. Esse modelo teve resultados promissores sobre o aprendizado de anatomia e habilidades clínicas, embora os próprios autores tenham afirmado que essa abordagem precisa de pesquisas adicionais para levar a resultados mais confiáveis e válidos.

3.2.12 Espelho Mágico

Uma tela grande e estática e o Microsoft Kinect - com a câmera voltada para o usuário para melhores visualizações da imagem digital na tela - foram usados como dispositivo de exibição

para o espelho mágico de realidade aumentada. A principal característica do sistema de realidade aumentada (espelho mágico) reside na probabilidade de mostrar partes anatômicas em diferentes modalidades e planos de seção, bem como em alternar interativamente entre elas[34]. Os alunos sugeriram melhorias no sistema, como a possibilidade de congelar a imagem de uma seção específica.

3.2.13 Poesia Médica

Este método foi elaborado em duas etapas. Grupos pequenos com 3 alunos criariam poesia com base em exemplos e diretrizes fornecidas pelo tutor, como tamanho, métricas e rima na primeira etapa. Na segunda etapa os alunos deveriam avaliar anatomicamente a poesia escrita pelos outros grupos[35].

3.2.14 Mímica

Os alunos assistiram a uma aula tradicional para aprender sobre a anatomia dos pares de nervos cranianos. Esta aula foi seguida por outra com mimica - os alunos usaram os mesmos slides para garantir que nenhum conteúdo adicional seria perdido. Ambas as classes foram substanciadas por testes pré e pós-aula[36]. As diferenças entre pré e pós-pontuação foram mais significativas quando a mimica foi adotada. No entanto, este estudo apresenta limitações, por exemplo, estudantes e professores não eram cegos para a pesquisa e a mesma palestra foi ministrada duas vezes para os mesmos alunos. Portanto, não foi possível distinguir se o melhor desempenho foi registrado devido ao mimetismo ou à repetição do conteúdo.

3.2.15 Aplicativo Móvel

O uso de aplicativos e sites acessados em smartphones para procurar informações é uma prática bastante comum entre os alunos. Um aplicativo específico para estruturas da orelha interna, conhecido como Buckingham Virtual Tympanum, carrega imagens para ajudar a identificar as estruturas normais e patológicas da membrana timpânica[37]. Outra abordagem considerou uma comparação entre o uso de e-book e métodos tradicionais, com resultados favoráveis ao uso do e-book[38].

3.2.16 Aprendizagem por Pares

Essa é uma abordagem colaborativa que facilita aos alunos o envolvimento no conteúdo do curso e a transformação do aprendizado, que é uma atividade privada, em social, além de praticar o compartilhamento de informações[39]. Para tanto, os alunos da turma foram divididos em grupos com 15 participantes para trabalhar nas mesas de dissecação. Todos os alunos assistiam às aulas pela manhã sobre a região anatômica a ser dissecada à tarde. Dois estudantes foram escolhidos aleatoriamente para participar de um treinamento pré-laboratorial de 45 minutos, para estarem prontos para ensinar seus colegas na mesa de dissecação. Todos os alunos tiveram a oportunidade de ser o "dissecador principal" e o "aprendiz". Nesse sentido, a sessão laboratorial foi dividida em duas etapas: os alunos ensinaram seus colegas em 75% do tempo e os professores esclareceram perguntas com toda a turma nos 25% restantes[39]. O "Módulos de sombra" foi outra abordagem adotada. Os alunos definiram os locais e a quantidade de reuniões e criaram seus próprios recursos de aprendizado e revisão, além de identificar recursos para acessar material público na Internet. Essa atividade fez com que os alunos compartilhassem informações amplamente e evidenciou que os próprios estudantes são recursos essenciais para o desenvolvimento de um aprendizado criativo e motivador[40].

3.2.17 Modelos Plásticos

Os modelos de plástico são uma das alternativas metodológicas mais promissoras. Os alunos passaram por muitas estações em um dos estudos para se acostumar com estruturas humanas plastificadas - palestras sobre anatomia radiológica e e-learning completaram a atividade[41]. Em outra abordagem, os alunos foram instruídos pelo tutor nos primeiros minutos e, posteriormente, tiveram que responder às perguntas e identificar as estruturas após concluir cada estação em 15 minutos. A última estação, chamada "página em branco", tinha uma atividade metacognitiva - um desenho podia ser esboçado no quadro branco ou representado com argila de modelagem. Posteriormente, as estruturas deveriam ser nomeadas sem a ajuda de qualquer material de suporte. Após o término da tarefa, os alunos puderam verificar o material disponível e corrigir seus erros[42]. Em um dos estudos, a universidade dispunha de impressora 3D, e os alunos foram envolvidos no processo de construção dos modelos, após a impressão em 3D, cada aluno coloriu sua peça, utilizando uma cor diferente para cada osso, rotulando-os posteriormente[43].

3.2.18 Simulação Prática

Foram descritas simulações para revisar o conteúdo das aulas de anatomia e o treinamento dos alunos para situações clínicas reais. Eles usaram o caso de um aluno / personagem que testemunhou uma conversa entre um médico e um estudante de medicina quando examinavam um paciente imaginário. O aluno / personagem e o estudante de medicina trabalharam juntos para resolver o caso e explicá-lo ao médico. Assim, os alunos responderam às perguntas sobre o caso em pequenos grupos[44]. Uma segunda abordagem de simulação prática foi realizada após uma aula tradicional, usando cadáveres levemente embalsamados em solução de glutaraldeído. Alguns estudantes aplicaram o teste de Lachman ao cadáver que apresentava um ligamento cruzado anterior (LCA) cirurgicamente rompido e a outros com LCA intacto[45].

3.2.19 Preceptor por Um Minuto

O método Preceptor por Um Minuto é baseado na teoria da aprendizagem de adultos. Ele fornece aos profissionais de ensino etapas práticas capazes de transformar perguntas de identificação de estrutura em oportunidades de aprendizado focadas no aluno. Consiste em 5 etapas, a saber: engajamento, “o que você acha que é?”; testando evidências , perguntando aos alunos por que eles acham que é dessa maneira e como eles chegam a essa resposta; reforçar a parte correta de um determinado raciocínio; corrigir os erros e cumprir as omissões; e ensinar uma regra geral ou uma questão-chave[46].

3.2.20 Quiz (software interativo baseado em quis)

O artigo avaliado abordou os efeitos de formatos verbais e visuais para aplicação de questionário em um ambiente de aprendizado ativo (Echo360, Dulles, VA), embora não tenha abordado detalhes sobre o software adotado. Exercícios em formato visual registraram melhores resultados e consistiram em questões de múltipla escolha associadas a imagens específicas ou em um mapa de imagens - os alunos deveriam clicar na imagem para responder às perguntas[47].

3.2.21 Aprendizagem baseada em equipe

Cada equipe do TBL tinha de 4 a 8 alunos e algumas mudanças foram observadas entre os estudos avaliados. Um deles aplicou o método em 4 etapas: (1) preparação individual - distribuição dos objetos de aprendizagem aos alunos uma semana antes da atividade; (2) fazer um teste de múltipla escolha (sozinho ou em grupo) - essa atividade foi seguida pela discussão de equívocos e

dúvidas individuais pelo facilitador; (3) caso clínico a ser discutido e analisado pelo grupo; (4) os alunos que participaram do TBL tiveram que explicar aos demais membros do grupo dissecador o que haviam aprendido naquele dia[48].

Outro estudo seguiu 4 etapas: (1) preparação individual; (2) aplicação de questionário; (3) discussão sobre "questões de aprendizado" com a ajuda do tutor; e (4) analisar o questionário com base nas respostas do grupo[49]. Uma abordagem diferente adotou os três primeiros estágios descritos acima; a atividade terminou após a reflexão e avaliação pelos pares[50].

É importante destacar que dar aos alunos a oportunidade de repetir os testes em um grupo de alunos não melhorou a retenção e o entendimento de conhecimentos, nem a pontuação no exame final[51]; além disso, os alunos vêem o feedback frequente como um instrumento importante[48].

Tabela 1 Principais potencialidades e fraquezas das abordagens ativas no ensino da anatomia humana

Autor (ano)	País	Curso	Sistema anatômico	Tipo de abordagem de aprendizagem ativa	Potencialidades e fraquezas das abordagens ativas avaliadas
Zumwalt et al. (2010)	Estados Unidos	Medicina	Anatomia Geral	Laboratório de aprendizagem ativo	Indicado para escolas que não possuem cadáveres. Entretanto é fundamental o engajamento entre anatomistas e ragiologistas para a atividade.
Jariyapong et al. (2016)	Tailândia	Medicina	Mãos	Pintura Corporal	Um método barato, interessante e agradável para os estudantes, facilita o ensino por pares, opção para a falta de cadáveres, pode ser aplicado em grandes turmas. Os alunos que estudaram as mãos indicam para outros sistemas.
Mcmenamin (2008)	Austrália	Medicina	Anatomia Geral		
Dickinson et al. (2018)	Estados Unidos	Medicina	Trato Gastrointestinal	Aprendizagem baseada em casos	Aumenta o envolvimento dos alunos dentro da sala de aula, a profundidade das discussões entre equipes, ajuda-os a aplicar conceitos das ciências básicas ao caso, entender melhor o processo da doença, e a complexidade do atendimento. Além disso, pode servir para introduzir novas relações ou reforçar as relações estrutura-função já apresentadas no curso. Entretanto, o grande tempo preciso para discussão pode acarretar na omissão de outra unidade curricular, e a atividade é dificultada quando aplicada em grandes grupos.
Kennedy (2013)	Estados Unidos	Psicologia	Nervoso		
Hofer, Nikolaus e Pawlina (2011)	Estados Unidos	Medicina	Anatomia Geral	Lista de Verificação	Ajuda os alunos a manterem o foco, não deixando passar conceitos/estruturas básicas e fundamentais para a compreensão da anatomia. Melhora o desempenho na dissecção e a média nos exames cognitivos.
Fitzpatrick, Finn e Campisi (2011)	Estados Unidos	Ciências da Saúde	Anatomia Geral	*Clickers*	Estimula o aprendizado ativo, a participação, a aplicação e o feedback sobre sua compreensão, considerado pelos alunos como muito eficaz. As desvantagens do uso dos clickers foram relacionados ao alto preço do dispositivo.

Rodenbaugh, Lujan e Dicarlo (2012)	Estados Unidos	Enfermagem	Músculo Esquelético	Construção de Modelos Físicos	Pode abordar a anatomia microscópica, como miofilamentos impossíveis de serem dissecados e traz uma visão bidimensional das estruturas muitas vezes possíveis de serem visualizadas apenas em um plano. Além disso, proporciona maior engajamento dos alunos na atividade. Todavia, os modelos construídos podem não oferecer mobilidade funcional para compreender a ação de contração/excitação dos músculos, e a abordagem requer maior tempo para a transferência do conhecimento do professor para o aluno quando comparada ao modelo tradicional de ensino
Noorafshan et al. (2014)	Irã	Medicina	Anatomia Geral	Desenho	Pode ser utilizada no ensino de toda anatomia humana, sem limitação de uso. Incentiva o equilibrio emocional e descolamento do laboratório de anatomia, ressalta a singularidade do corpo humano, com as diferenças anatômicas de cada indivíduo. Promove catarse e redução do estresse dos alunos, que também consideram ser uma estratégia de ensino divertida e que reduz o tempo de aprendizagem. Todavia, o uso dessa técnica requer tempo, planejamento, compromisso com o processo de ensino e a crença de resultados mais agradáveis e produtivos, e é sugerido uma avaliação associada para maior engajamento dos alunos.
Grogan e Ferguson (2018)	Estados Unidos	Medicina			
Dirks-Naylor (2016)	Estados Unidos	Farmácia	Renal		
Langfield, Colthorpe e Ainscough (2018)	Austrália	Terapia Ocupacional e Fisioterapia	Membros superiores	Aprendizagem Online	Quando utilizado como preparação paras aulas, promove uma postura mais ativa dos alunos na sala de aula, encorajando-os também com o estudo precoce do conteúdo, evitando dessa maneira, o acúmulo de matérias em véspera de prova, alunos consideram ganhos em aprofundamento, revisão e substituição do tutor. Entretanto, como fragilidade do método, pode-se apontar a dependência da autodisciplina e motivação do aluno, e quando feito por videoaulas, o aluno pode tomar uma postura passiva em relação aos vídeos, prejudicial para o ensino.
Kish, Cook e Kis (2013)	Hungria	Medicina	Anatomia Geral		
Lochner et al. (2016)	Itália	Fonoaudiologia e técnicas laboratoriais biomédicas			
Park e Howell (2015)	Estados Unidos	Odontologia	Anatomia Dentária	Sala de Aula Invertida	Desempenho igual ou superior às abordagens tradicionais, além de mais divertidas, interativas e colaborativas. Apresenta ganhos na retenção do conhecimento. O aluno se mantém atualizado com o conteúdo, tem mais oportunidades de autoavaliação do seu conhecimento, o professor pode avaliar os alunos quanto ao que aprenderam, identificar equívocos e ajudá-los a aplicar seus conhecimentos a novas situações clínicas. Habilidades psicomotoras são aprimoradas. Entretanto, o sucesso da metodologia é
Obrez et al. (2011)	Estados Unidos	Odontologia			
Kellesarian (2018)	Estados Unidos	Odontologia			

Shaffer (2016)	Estados Unidos	Ciências Biológicas e Enfermagem	Anatomia Geral		muito dependente da autodisciplina, maturidade e motivação do aluno, que pode sentir tensão entre a expectativa e o design do curso, a falta de feedback e orientação também pode comprometer sua eficácia educacional. Alguns alunos são mais dependentes do professor, sentindo-se incomodados ao estudarem sozinhos.
Bingen et al. (2019)	Norway	Enfermagem			
Day (2018)	Estados Unidos	Fisioterapia			
Whelan et al. (2016)	Canadá	Medicina			
Pickering e Roberts (2017)	Reino Unido	Medicina			
Burleson e Olimpo (2016)	Estados Unidos	Faculdade de Artes Liberais	Anatomia Geral	Aprendizagem baseada em jogos	Divertido, eficaz e de baixo custo, aumenta a compreensão sobre terminologias básicas. Considerado pelos alunos como sendo útil na preparação para exames. As dificuldades da abordagem é que os alunos preferem jogar com seus semelhantes, e o seguimento dos jogos depende de preparação prévia dos mesmos.
Mccarroll, Pohle-krauza e Martin (2009)	Estados Unidos	Ciência do Exército	Músculo Esquelético		
Rondon, Sassi e Andrade (2013)	Brasil	Fonoaudiologia	Cabeça e pescoço		
Ang et al. (2018)	Singapura	Medicina	Anatomia Geral		
Collett et al. (2009)	Inglaterra	Medicina	Anatomia Geral	Modelos Vivos	Proporciona a demonstração de variações anatômicas, características da superficie corporal e sexuais secundárias, reforça a humanização, e os modelos atuam ativamente no processo de ensino encorajando os alunos a lhes fazerem perguntas, palpação de seus corpos, orientando-os sobre o conteúdo anatômico, fornecendo feedback individual durante o exame para o aluno e para o tutor, capacitando os alunos a se tornarem aptos e confortáveis para lidar com o corpo vivo sem constrangimento ou inaptidão. O maior entrave é conseguir os modelos vivos que precisam de serem treinados para a atividade.

Kugelmann et al. (2018)	Alemanha	Medicina	Anatomia Geral	Espelho Mágico	Its interactive component motivates active learning and improves the 3D sense. There are impairments if a high-quality provider/software is not available.
Carnegie (2012)	Canadá	Ciências da Saúde	Anatomia Geral	Poesia Médica	Promove a retenção de informações além da simples memorização, os alunos ainda revisam informações da anatomia para a criação dos poemas. Entretanto, o método parece não ter muita adesão entre os estudantes.
Dickson e Stephens (2015)	Austrália	Ciências Biomédicas	Nervous	Mímica	Comparado à aula tradicional, os estudantes consideraram a aula de mímica mais interativa, envolvente, eficaz e motivadora. O artigo traz limitações importantes, e por isso a metodologia ainda deve ser melhor estudada para resultados mais precisos.
Samra, Wu e Redleaf (2016)	Estados Unidos	Medicina	Sistema Auditivo	Aplicativo Móvel	Demonstraram aumento no desempenho dos alunos e na exposição ao conteúdo. É um simulador portátil (celular), e o design pode se adequar as necessidades dos alunos e/ou da matéria. Como fragilidade do método, pode-se constar que quando aplicado por e-book os alunos podem se sentir desconfortáveis, todavia é uma sensação superada com o tempo de uso.
Stirling e Birt (2014)	Austrália	Medicina	Anatomia Geral		
Manyama et al. (2016)	Tanzânia	Medicina	Anatomia Geral	Aprendizagem por Pares	Aumenta a média geral da turma beneficiando principalmente os alunos de baixo rendimento. Para os alunos tem como benefícios o aprimoramento da aprendizagem, uso eficiente do tempo, construção de confiança entre os alunos, experiência em ensinar, a necessidade de domínio do assunto para ensinar, e o desenvolvimento de postura profissional e habilidades de comunicação. Entretanto, os alunos podem promover um ensino inadequado à turma, além do risco de tornar-se seminários ao invés de ensino por pares.
Scott, Moxham e Rutherford (2014)	Estados Unidos	Medicina			
Fruhstorfer et al. (2011)	Reino Unido	Medicina	Anatomia Geral	Modelos Plásticos	Quando comparado às leituras, estudos de casos em pequenos grupos e sessões de radiologia, a maioria dos alunos classificaram os modelos plásticos como primeira opção para maior eficácia na aprendizagem da anatomia. Permite visualização mais detalhada pela qualidade da dissecção e reduz o tempo de estudo por ja ter as peças prontas. O método também conta com a vantagem de o aluno poder visualizar relações espaciais e ser capaz de acessar a peça em qualquer lugar a qualquer momento. Todavia, a delicadeza e alto valor das peças inibem os alunos, que tendem a limitar-se apenas ao contato visual, a rigidez das peças impede a mobilidade dos tecidos moles, perde a textura natural e não familiariza o estudante com a
Naug, Colson e Donner (2011)	Austrália	Medicina			
Backhouse, Taylor e Armitage (2018)	Austrália	Medicina	Olhos		

					experiência de morte. Quando a peça é feita por impressora 3D os alunos relataram a perda de fidelidade com a peça natural.
Lemons (2017)	Austrália	Medicina	Nervoso	Simulação Prática	Promove maior compreensão da anatomia, evidenciada pelo melhor desempenho nos testes cognitivos, maior eficácia diagnóstica nos exames físicos, retenção do conhecimento, e é muito atrativa para os alunos.
Keim Janssen et al. (2014)	Estados Unidos	Medicina	Músculo Esquelético		
Chan e Wiseman (2011)	China	Medicina	Anatomia Geral	Preceptor por um minuto	Preferível pelos alunos ao método tradicional por ter pontos de ensino sucinto, centrado nas dificuldades do aluno, e maior envolvimento em processos de raciocínio, preparação para a aprendizagem clínica, além do feedback imediato.
Gross, Wright e Anderson (2017)	Estados Unidos	Ciência do Movimento / Cinesiologia	Músculo Esquelético	Quiz (software interativo baseado em quis)	Útil para ver imagens de ideias chaves do curso, como revisão de exames, esclarece dúvidas, e gera maior interesse por parte do aluno. Questões associadas com imagem geraram melhores resultados do que as que utilizam apenas textos.
Huitt, Killins e Brooks (2015)	Estados Unidos	Fisioterapia	Cabeça e pescoço	Aprendizagem Baseada em Equipes	Promove a retenção do conhecimento, um desempenho superior nos exames cognitivos quando comparado aos alunos de método tradicional, na preparação para exames e no desenvolvimento de habilidades de trabalho em equipe. Entretanto, pode-se encontrar resistência ao método devido uma atmosfera competitiva entre os alunos.
Vasan, Defouw e Holland (2008)	Estados Unidos	Medicina	Anatomia Geral		
Inuwa (2012)	Omã	Medicina			
Green et al. (2016)	Austrália	Ciências do Exercício, Ciências da Saúde, Ciências e Ciências Biomédicas			

4. CONSIDERAÇÕES FINAIS

Atualmente, vivenciamos mudanças na matriz curricular e elas exigem treinamento de professores, bem como integração horizontal e vertical de ciências básicas e clínicas. Esse processo contribui para uma mudança global na redução da carga de trabalho no ensino de anatomia e a falta de cadáveres em comparação com o crescente número de estudantes. Assim, acreditamos na importância de introduzir novas abordagens metodológicas no ensino da anatomia humana. No geral, os estudos avaliados não mostraram diferenças na aprendizagem cognitiva em comparação com a abordagem tradicional de ensino. A maioria dos casos mostrou ganho de competências e aumento do conhecimento de autonomia dos alunos, além de melhor planejamento e envolvimento dos professores. Além do mais, os estudantes estão mais motivados e interessados em estratégias inovadoras, embora precisem de orientação e feedback sobre suas práticas. Além disso, é importante destacar a probabilidade de sobrecarga nas atividades realizadas pelos alunos (principalmente os que exigem preparação prévia para aulas posteriores, como sala de aula invertida). Assim, é essencial esclarecer os objetivos de aprendizagem da turma, para que a abordagem ativa escolhida possa ser a mais adequada possível.

As metodologias ativas de ensino têm a vantagem de se adaptar às necessidades de cada universidade, de cada aluno e de cada disciplina a ser ministrada. Contamos com toda uma variedade de abordagens ativas e elas podem ser combinadas e ajustadas com base nos recursos, necessidades e objetivos de ensino. Além disso, observamos que poucos estudos realmente abordaram o uso, benefícios e / ou vantagens das abordagens ativas para o processo de ensino-aprendizagem em anatomia humana. Assumidamente, mais estudos devem ser realizados para avaliar o custo / benefício real, vantagens, desvantagens, potencialidades e fragilidades das abordagens ativas na anatomia humana.

5. DECLARAÇÃO DE INTERESSE

Nenhum conflito de interesses foi relatado pelos autores.

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  Trelease RB. 2015. Essential e-learning and m-learning methods for teaching anatomy. In: Chan LK, Pawlina W (Editors). Teaching Anatomy: A Practical Guide. 1st Ed. New York, NY: Springer International Publishing. p 247–258.

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Michaelsen LK, Knight AB, Fink LD. 2004. Team-Based Learning: A Transformative Use of Small Groups in College Teaching. 1st Ed. Sterling, VA: Stylus Publishing, LLC. 286 p.

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Guillot GM. 2014. Does time matter? A search for meaningful medical school faculty cohorts. Indiana University: Indianapolis, IN. Doctorate of Philosophy Dissertation. 267 p.

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Pawlina W, Blankers TR, Lachman N, Bhagra A. 2016. Collaborative ultrasound objective structural practical examination (OSPE) in gross anatomy. In: Abstracts of AMEE 2016 Conference; Barcelona, Spain, 2016 August 28–31. Abstract 9FF04. Association for Medical Education in Europe: Dundee, Scotland, UK.

For abstracts printed in journals and periodicals include the author's names; year of publication; abstract title; abbreviated title of the journal or periodical according to Index Medicus; volume number; and abstract identification number or inclusive pages. Please follow the format given below.

Brokaw JJ, Jones KJ. 2014. Outsourcing anatomists: A model for expanding educational outreach and providing supplemental revenue to anatomy departments. FASEB J 28:S721.22.

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Acland RD. 2013. Acland's Video Atlas of Human Anatomy. Wolters Kluwer Health/Lippincott, Williams & Wilkins, Baltimore, MD. URL: http://aclandanatomy. com/ [accessed 13 October 2016].

Wise L, Skues J, Williams B. 2011. Facebook in higher education promotes social but not academic engagement. In: Williams G, Statham P, Brown N, Cleland B (Editors). Proceedings of Annual Australasian Society for Computers in Learning in Tertiary Education (ASCILITE 2011) Conference: Changing Demands, Changing Directions; Hobart, Tasmania, Australia, 2011 December 4–7. p 1332–1342. Australasian Society for Computers in Learning in Tertiary Education, Tugun, QLD, Australia. URL: http://www.ascilite.org/conferences/hobart11/downloads/ papers/Wise-full.pdf [accessed 13 October 2016].

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Example: *In the last few years, medical schools have been adopting TBL in preclinical courses (Siedel and Richards, 2001; McInerney, 2003; Nieder et al., 2005), clerkships, and resident training (Hunt et al., 2003a,b).*

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Anatomical Sciences Education

Active teaching and learning methodologies in Anatomy: a systematic review

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Active teaching and learning methodologies in Anatomy: a systematic review

Running Head: Active teaching and learning in Anatomy

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- Acquisition, analysis and interpretation of data: Dagostin, Silva, Kennedy-Feitosa and Moraes
- Writing of the manuscript: Dagostin, Silva, Kennedy-Feitosa and Moraes
- Drafting and critical revision of the manuscript for important intellectual content: Dagostin, Silva, Kennedy-Feitosa and Moraes.

ABSTRACT

Anatomy traditional education has been gradually replaced by a range of active learning approaches that favor the development of competences relation to knowledge, skills and attitudes. This study aimed to identify, synthesize and demonstrate the use and implementation of the main active approaches used in human anatomy, highlighting their potentialities and weaknesses. We identified empirical studies discussing the use of learning modalities active in the teaching of human anatomy via PubMed search. Two researchers independently assessed the eligibility of the studies by title, abstract, full-text review. Data tabulation and narrative analysis of study findings was performed. We screened 45 full-text articles met criteria for inclusion in the review. A total of twenty one active learning approaches were identified. Flipped classroom and team-based learning were the most utilized approaches. Active approaches promote gains in student attitudinal competencies, autonomy and motivation. On the other hand, active learning methodologies demand more strategic planning by the teacher and feedback to students.

KEYWORDS: Active learning; Anatomy; Students; Education; Teaching/methods.

INTRODUCTION

Since the emergence of the first medical universities, a traditional teacher-centered method has been predominantly employed. From the 20th century, a reform of medical curricula began to be questioned in order to follow the socioeconomic and technological changes that occurred in society. In 1900, Abraham Flexner's report "Medical Education in United States and Canada" reaffirmed the traditional methodology centered on the disease, in an individual and concrete way. In 1984, American Association of Medical Colleges discussed again this problem by publishing two reports on curriculum reform, demonstrating the increasing use of active methodologies and problem-based learning (Drake, 2014). This placed North America as the cradle of active teaching methodologies (Hildebrandt, 2010). Although the need for changes in medical education has been a hot topic nowadays, few discussions occurred until the late nineteenth century.

Traditional anatomy teaching through lectures and dissections has been replaced by modules comprising problem-based learning (PBL), plastic or computer models, and curriculum integration (Papa e Vaccarezza, 2013). However, these new approaches must be carefully considered, because although effective in teaching anatomy, they should be evaluated for effectiveness in making the learning process constructive for students (Torres et al., 2014). None methodology is absolutely superior to the other. Some schools, such as Harvard, try to make the most of the benefits of different teaching methods by integrating them (Johnson, 2012), encompassing different active approaches and as few traditional classes as possible (Yiou e Goodenough, 2006). In this context, the objective of this article is to systematically review the literature on the use, effectiveness, strengths and

weakness of the main active methodologies used in human anatomy teaching in recent years.

MATERIAL AND METHODS

Search strategy

A comprehensive literature search was conducted by one of the authors (Dagostin). Database searched was PubMed. Search terms included index terms (MeSH terms) and free text words:"*active learning"* AND *"anatomy*". The searches were limited to English-language and filters fields "Title/abstract" (filters) journal articles published between 2000 and 2019. Overall, the authors felt a 20-year limit was appropriate to ensure the data being evaluated was applicable in undergraduate medical education today.

Study selection

All articles retrieved were screened for full-text review if they were original research articles that assessed the use of active learning in human anatomy. Active learning was defined according to Bonwell and Eison (Bonwell e Eison, 1991) as any instructional method that engages students in the learning process, according to these authors "instructional activities involving students in doing things and thinking about what they are doing" (Bonwell e Eison, 1991). Paired reviewers (Dagostin and Moraes) screened titles and abstracts of retrieved articles independently. Citations with abstracts that seemed potentially relevant to the selection criteria were included as candidates for full-text screening. The same two reviewers screened these full text articles independently and in duplicate based on the selection criteria. Editorials, comments, autobiographies, letters, survey research studies, and reviews were excluded. When a discrepancy arose in article selection between the two reviewers at the full-text article

screening stage, the disagreement went to arbitration by a third reviewer (Silva) who served as a tiebreaker.

Data extraction

The systematic review was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Statement (PRISMA) (Moher et al., 2009). A standard extraction framework was developed to abstract and code data from the selected studies. The two authors (Dagostin and Moraes) read each article independently and used the extraction framework to extract data. Data was extracted on the country where the study took place, type of course, type of systems anatomy, type of active learning (team-based learning, problem-based learning, etc.), and potentialities and weakness of active learning being evaluated. This information can be found in Table 1.

RESULTS AND DISCUSSION

Retrieved studies

One hundred fifty-three potentially eligible articles were identified in the PubMed database. A further 107 articles were excluded after title and/or abstract screening leaving 45 for full-text review. Excluded articles presented different themes from the one chosen in our study such as radiology, neurology, histology, among others, or do not discussed active approaches in the teaching of human anatomy. Final selection of the publications identified in PUBMED database resulted in 45 articles that met the previously established inclusion criteria and were submitted to—exploratory and descriptive data analysis (Table 1). Further details shown in PRISMA flowchart (Figure 1).

Study characteristics included by teaching methodology

This systematic review examined the role of active learning in human anatomy

in undergraduate education. It revealed a large number of variations in approaches to active learning. Due to the heterogeneity of these studies, it was difficult to assess the overall effectiveness and utility of these learning approaches for human anatomy. Despite, the overall outcomes were positive and the approaches evaluated are described below.

Active Learning Laboratory

Anatomy laboratory provides an ideal environment for utilization of active methods. A study described the use of four stations, the first two being composed of a plastic articulated skeleton on a table, an atlas and supplements (foam, tubing, etc.) to represent muscles, vessels, and nerves. Students should construct a femoral triangle model (station 1) and the region around the supraclavicular fossa (station 2). In station 3 was provided plastic skeleton and radiological images of the shoulder and pelvis. At this station, students combined the structures marked on images with the structures marked in the skeleton, naming the structures. At the last station an ultrasound operator guided students showing characteristics of the images in the neck and upper limbs, the students themselves took turns acting as patients at this station. After passing through all the stations, the class discussed the content (Zumwalt et al., 2010).

Body Painting

Body painting was performed to teacher anatomy of hand (Jariyapong et al., 2016), face, respiratory system, skeletal muscle, head and neck (McMenamin, 2008). Each student had 20 minutes to paint himself hand, 20 minutes to paint the hand of the other student and 20 minutes to discussion comparing with other students that participated of traditional class only for 1 hour. The test done immediately after and one month later the students did not have the significative differences on the total

score, but to specific questions about painted surface the other students had the better performance (Jariyapong et al., 2016).

Case-Based Learning

Case-based learning uses patient cases to encourage discussions, questioning, problem solving and reasoning about matters concerning basic and clinical sciences (Dickinson et al., 2018). It has several applications such as the theoretical development by the instructor of anatomy relevant for the case, case presentation to the students, triggering discussions in small groups and debates with the whole class in order to answer previously handed out questions (Kennedy, 2013). Introducing the interview, history of medication, image and laboratory exams and findings in real physical examinations in patients are other ways to use the case-based learning, as well as to discuss the case and questions answered in small groups with the help of the professor (Dickinson et al., 2018).

Checklist

It is strategically used to guide students' anatomical studies, since it assures that the main structures will be approached. The checklist can be printed at any time during the class, because, according to the students, it is better than getting it by email. It can also be written on the white board at the laboratory (Hofer et al., 2011).

Clickers

The *Personal response systems,* also known as *clickers*, are equipment similar to a remote control. Each student clicks a bottom to choose a fast answer to questions addressed by the professor on projected slides. The assessed study was based on group discussions and on collective decisions substantiated by the given

answers (FitzPatrick et al., 2011). Clickers can be associated with other active approaches such as the team-based learning (TBL). This practice favors the collection of individual and group answers, since it provides immediate feedback for group discussions, a fact that is considered essential for significant learning.

Construction of Physical Models

Students assemble the scheme of the skeletal muscle based on the Socratic Method by using laces at different colors, string of beads, paper tubes and aluminum paper – each material represents the components of myofilaments (Rodenbaugh et al., 2012). This model emphasizes partition and the biomechanical aspects of the excitation-contraction coupling at sarcomere level, but it does not approach other aspects of it. In order to have an alternative to such obstacle, the idea is to add computer animations and/or simulations; moreover, students are asked to creatively change the model to approach these other aspects.

Drawing

The case-based learning can be applied to anatomy learning as a whole; its use is unlimited (Noorafshan et al., 2014). An experiment, based on which students draw the bodies in front of them, was described. They drew the bodies instead of dissecting them, it was done in order to highlight the limitations of printed and digital images of the body (Grogan e Ferguson, 2018). Another experiment was based on the generation of a diagram/figure by labeling the function of the structures, as well as the action of the used drugs and hormones, and problem solving or answers given to a question (in pairs or in group) – the whole process ended with an open discussion (Dirks-Naylor, 2016). Another report concerned the use of an anatomical draft along with the projection of drawings (Noorafshan et al., 2014). The brain is

actively engaged in analyzing the appropriate direction and position of anatomical structures when the individual is drawing them (Dirks-Naylor, 2016); therefore, this process contributes to students' learning.

E-learning

The *E-learning* technique enables endless learning possibilities to students. The use of instructing videos applied as guidelines was identified, this procedure was based on adopting parts identical to the ones available to students in the laboratory - it indicates specific structures to guide the learning aims (Langfield et al., 2018). Another approach was based on a workshop about anatomy dependent on computer assistance. These classes aimed at helping students to better understand medical digital images and to improve their ability to navigate through computer images. The Virtual Human Dissector (VHD) software and the free access website Human Anatomy Online were the main teaching tools of this teaching module (Kish, et al., 2013). A third study spent 7 of the 30 hours scheduled to the workshop in online activities performed in the software Integrated Learning, Information and Work Cooperation System (ILIAS®). These activities were divided into 3 stages, namely: exercises to fill the blanks, an online video about human anatomy and another with clinical examples, a test related to the videos (Lochner et al., 2016).

Flipped classroom

The primary aim of a flipped classroom is to set a learning environment focused on the student, based on active and collaborative learning (Park e Howell, 2015). Traditional practices applied in classroom environments are performed at home (before the class), and assignments often conducted at home are finished during class hours. The studies to be assessed are sent a week before, and the

support material (the sheet with the questions to be answered) should be answered and sent back before the class (Kellesarian, 2018; Obrez et al., 2011). Another study was based on applying a test before the class (Park e Howell, 2015), or even on the use of reading guidelines with questions to evaluate students' understanding about their readings (Shaffer, 2016). These approaches enable assessing class preparation, since the method depends on this stage to be successful. The combined use of digital technologies has been showing promising results (Bingen et al., 2019; Kellesarian, 2018; Park e Howell, 2015), and students who have adopted this approach were able to answer questions about the high complexity of Bloom Taxonomy with greater precision (application and analysis) (Day, 2018). However, many authors emphasize the need of having a careful analysis about the necessary workload for students by balancing the pre-class material, as well as by setting clear learning targets and the expected outcomes (Bingen et al., 2019; Kellesarian, 2018; Park e Howell, 2015; Shaffer, 2016; Whelan et al., 2016).

Game Based Learning

There are countless games that can be used or adapted to anatomy teaching. The adaptation of the board game named Funglish, which has descriptive cards with nouns, was reported. The new game was called ClueConnect, its descriptive cards were replaced by cards with adjectives and verbs about anatomy. The categories included anatomic directions (upper or distal, for example), tissue type (epithelial or secretory, for example), quality (elastic or hollow, for example) and actions (communicates or articulates, for example) (Burleson e Olimpo, 2016). There was another study (McCarroll et al., 2009) whose students embodied a muscle profile; they introduced themselves to the colleagues using the name of the muscle, its

origin, insertion and action. They had to show a functional exercise of such muscle and the other students had to find its pair (antagonistic to the primary muscle). Tests were carried out in the Anatesse 2.0 software, which has animations, chapter support and self-study quiz-type tests to be answered in group (Rondon et al., 2013).

Living Models

Actors dressing large garments and flip-flops were used to easily identify anatomic features in their bodies (Collett et al., 2009). This model had promising results over anatomy learning and clinical skills, although authors themselves stated that this approach needs additional research in order to lead to more reliable and valid results.

Magic Mirror

A big and static screen and the Microsoft Kinect – with its camera turned to the user for better visualizations of the digital image on the screen - were used as exhibition device for the augmented reality magic mirror. The main feature of the augmented reality system (magic mirror) lies on the likelihood of showing anatomic parts at different modalities and section planes, as well as on interactively alternating between them (Kugelmann et al., 2018). Students suggested improvements in the system, such as the possibility of freezing the image of a specific section.

Medical Poetry

This method was elaborated in two stages. Small groups with 3 students would create poetry based on examples and guidelines provided by the tutor, such as size, metrics and rime in the first stage. Students in the second stage were supposed to anatomically evaluate the poetry written by the other groups (Carnegie, 2012).

Mimicry

Students attended a traditional class to learn about the anatomy of the pairs of cranial nerves. This class was followed by one with mimicry – students used the same slides in order to assure that no additional content would be lost. Both classes were substantiated by pre- and post-class tests (Dickson e Stephens, 2015). Differences between pre- and post-scores were more significant when mimicry was adopted. However, this study presents limitations, for instance, students and professors were not blind to the research and the same lecture was given twice to the same students. Therefore, it was not possible distinguishing whether the best performance was recorded due to the mimicry or to content repetition.

Mobile App

The use of applications and websites accessed in smartphones to search for information is a quite common practice among students. An application specific for inner ear structures known as *Buckingham Virtual Tympanum* carries images to help identifying the normal and pathological structures of the tympanic membrane (Samra et al., 2016). Other approach regarded a comparison between eBook using and traditional methods – results pointed towards the favorable use of eBook (Stirling e Birt, 2014).

Peer Learning

This is a collaborative approach that makes it easier for students to engage in the content of the course and to turn learning, which is a private activity, into a social one, as well as to practice information sharing (Manyama et al., 2016). In order to do so, students in the class were divided into groups with 15 participants to work at

dissecting tables. All students would attend class in the morning about the anatomic region to be dissected in the afternoon. Two students were randomly chosen to attend a 45-minute pre-laboratory qualification training, so they would be ready to teach their colleagues at the dissecting table. All students had the opportunity to be the “main dissector” and the “apprentice”. Accordingly, the laboratory session was divided into two stages: students taught their peers in 75% of the time and professors clarified questions with the whole class in the remaining 25% of it (Manyama et al., 2016). The “Shadow Modules” was another adopted approach. Based on it, students set the places for, and the amount of, meetings, they created their own learning and review resources, as well as identified resources to access public material in the internet. This activity made students broadly share information, and it evidenced that students themselves are essential resources to the development of creative and motivating learning (Scott et al., 2014).

Plastic Models

Plastic models are one of the most promising methodological alternatives. Students went through many stations in one of the studies in order to get used to plasticized human structures – lectures about radiological anatomy and e-learning completed the activity (Fruhstorfer et al., 2011). In another approach, students were instructed by the tutor in the first minutes and, later on, they had to answer the questions and to identify the structures after completing each station within 15 minutes. Finally, the station called “white page” had a metacognitive activity - a drawing could be drafted on the white board or depicted with modeling clay. Subsequently, the structures should be named without the help of any support material. After the assignment was over, students could check on the material

available and correct their mistakes (Naug et al., 2011). The university had a 3D printer; students got involved in the process to build the models. Each student assembled its part after the 3D item was ready, each bone had a different color – bones were labeled later (Backhouse et al., 2018).

Practical Simulation

Simulations were described in order to review anatomy class contents and students' training for real clinical situations. They used the case of a student/character who witnessed a conversation between a doctor and a medical school student when they were examining an imaginary patient. The student/character and the medical school student worked together to solve the case and to explain it to the doctor. Thus, students answered the questions about the case in small groups (Lemons, 2017). A second practical simulation approach was carried out after a traditional class by using corpses slightly embalmed in glutaraldehyde solution. Some students applied the Lachman test to the corpse who had a surgically disrupted anterior cruciate ligament (ACL) and to others with intact ACL (Keim et al., 2014).

Preceptor for 1 minute

The Preceptor for 1 method is based on the adult learning theory. It provides teaching professionals with practical steps capable of turning structure-identification questions into learning opportunities focused on the student. It consists of 5 stages, namely: engagement, "what do you think it is?"; testing the evidence, asking students why they think it is this way and how they go to such answer; reinforcing the correct part of a given reasoning; correcting the mistakes and fulfilling the omissions; and teaching an overall rule or a key-issue (Chan e Wiseman, 2011).

Quiz (software-based interactive quiz)

The assessed article addressed the effects of verbal and visual formats for quiz application in an active learning environment (Echo360, Dulles, VA), although it did not approach details about the adopted software. Exercises in visual format recorded better results and consisted in multiple choice questions associated with specific images or in an image map - students were supposed to click on the image to answer the questions (Gross et al., 2017).

Team Based-Learning (TBL)

Each team in TBL had from 4 to 8 students and some changes could be observed between the assessed studies. One of them applied the method in 4 stages, name: (1) individual preparation - distribution of learning objects to students one week before the activity; (2) taking a multiple choice test (alone or in a group) – this activity was followed by the discussion of misconceptions and individual doubts by the facilitator; (3) clinical case to be discussed and analyzed by the group; (4) students who participated in the TBL had to explain to the others in their dissecting group about what they had learned at that day (Huitt et al., 2015).

Another study followed 4 stages: (1) individual preparation; (2) quiz application; (3) discussion about “learning issues” with the help of the tutor; and (4) analyzing the quiz based on group answers (Vasan et al., 2008). A different approach adopted the first three stages described above; the activity was over after the reflection and assessment by the peers (Inuwa, 2012).

It is important highlighting that giving students the opportunity to repeat the tests in a group of students did not improve their knowledge retention and

understanding, or their score in the final exam (Green et al., 2016); moreover, students see frequent feedback as an important instrument (Huitt et al., 2015).

FINAL CONSIDERATIONS

Nowadays, we have been experiencing changes in the curriculum matrix and they demand professors' training, as well as horizontal and vertical integration of basic and clinical sciences. This process adds to a global move to reduce workload in anatomy teaching and to lack of corpses in comparison to the growing number of students. Accordingly, we believe in the importance of introducing new methodological approaches in human anatomy teaching. Overall, the assessed studies did not show differences in cognitive learning in comparison to the traditional teaching approach. Most cases had shown gain in competences and increased autonomy knowledge by students, as well as better planning and professors' involvement. Moreover, students are more motivated and interested in innovative strategies, although they need guidance and feedback about their practices. Besides, it is important highlighting the likelihood of overload in activities carried out by students (mainly the ones demanding previous preparation for further classes, such as reversed classroom). Thus, it is essential to clarify the learning targets of the class, so that the chosen active approach can be the most adequate possible.

Active teaching methodologies have the advantage of adjusting to the needs of each university, of each student and of each discipline to be taught. We count on a whole variety of active approaches and they can be combined and adjusted based on the resources, needs and teaching goals. In addition, we observed that few studies actually addressed the use, benefits and/or advantages of the active approaches for the teaching-learning process in human anatomy. Assumingly, more studies must be

carried out in order to assess the real cost/benefits, advantages, disadvantages, potentialities and fragilities of the active approaches in human anatomy.

DECLARATION OF INTEREST STATEMENT

No potential conflict of interest was reported by the authors.

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Figure legend

Figure 1 Flowchart of study selection process

Table legend

Table 1 Main potentialities and weaknesses in active approaches in teaching human anatomy

Table 1 Main potentialities and weaknesses in active approaches in teaching human anatomy

Author (year)	Country	Type of course	Systems anatomy	Type of Active learning approaches	Potential and weaknesses of active learning evaluated
Zumwalt et al. (2010)	United States of America	Medicine	Geral Anatomy	Active Learning Laboratory	It is indicated to schools that do not have corpses. However, it is essential joining anatomists and radiologists in the activity.
Jariyapong et al. (2016)	Thailand	Medicine	Hands	Body Painting	A cheap, interesting and pleasant method that makes learning from peers easier. It is an option for lack of corpses that can be adopted in classrooms with a large number of students. Students who have studied the anatomy of the hands indicate such method to the others.
Mcmenamin (2008)	Australia	Medicine	Geral Anatomy		
Dickinson et al. (2018)	United States of America	Medicine	Gastrointestinal tract	Case Based Learning	It encourages students to engage in class activities, to deepen into discussions between work teams by helping them to apply basic scientific concepts to the cases, to better understand the process of the disease and the complexity of medical assistance. Besides, it can work as a tool to introduce new relationships or to reinforce the structure/function relation addressed throughout the course. However, the longtime demanded by the discussions can lead to omission of other curriculum units; therefore, this is not a good tool for classes with too many students.
Kennedy (2013)	United States of America	Biological Psychology	Nervous		
Hofer, Nikolaus e Pawlina (2011)	United States of America	Medicine	Geral Anatomy	*Check list*	It helps students to focus, since it addresses basic and fundamental concepts/structures for better understanding anatomy. It improves performance at dissection and the scores in cognitive tests.
Fitzpatrick, Finn e Campisi (2011)	United States of America	Health Sciences	Geral Anatomy	*Clickers*	It encourages active learning, participation, application and feedback about its understanding. It is considered effective by the students. Disadvantages of using clickers were related to the high price of the devices.

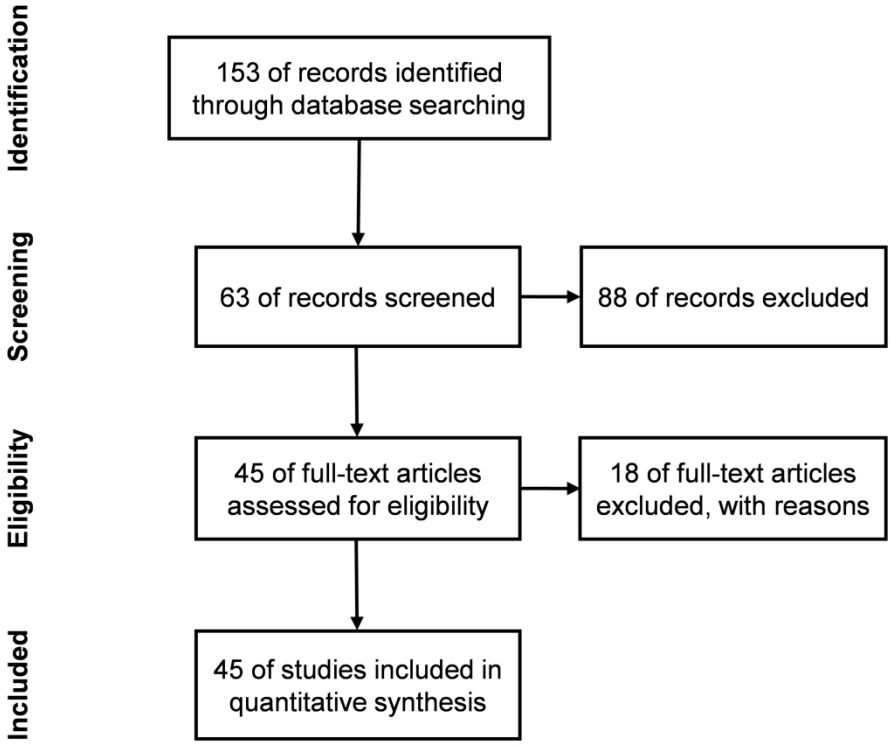
Rodenbaugh, Lujan e Dicarlo (2012)	united States of America	Nursing	Skeletal Muscle	Construction of physical models	It can approach the microscopic anatomy such as myofilaments, which are impossible to be dissected. Besides, it brings a 2D view of structures often possible to be seen in only one point. Moreover, it allows greater engagement of students in the activity. However, the generated models do not provide functional mobility to better understand muscles' contraction/excitation actions. The approach requires longer time to transfer knowledge from the professor to the students than the traditional teaching model.
Noorafshan et al. (2014)	Iran	Medicine	Geral Anatomy	Drawing	It can be used to teach human anatomy as a whole; its use is unlimited. It encourages emotional balance and distancing from the anatomy laboratory; besides, it highlights the singularity of human body and the anatomic differences of each individual. It causes catharsis and stress reduction in students who also see it as a fun teaching strategy capable of shortening learning time. However, this technique demands time, planning, commitment to the learning process and trust on more pleasant and productive outcomes. The method suggests a test associated with greater students' engagement.
Grogan e Ferguson (2018)	United States of America	Medicine			
Dirks-Naylor (2016)	United States of America	Pharmacy	Renal		
Langfield, Colthorpe e Ainscough (2018)	Australia	Occupational Therapy and Physical therapy	Upper Limbs		This technique leads to a more active attitude by students in classroom when it is used for class preparation. It encourages them to use early contents in order to avoid the accumulation of subjects to be studied before the test. Students can feel the gains from deepening in the subjects, from the reviews and from tutor's replacement. However, one of the methods' limitation lies on its dependence on self-discipline and self-motivation. The student can have a passive attitude towards the videos when the assignment is acquired through online classes, a fact that can impair the learning process.
Kish, Cook e Kis (2013)	Hungary	Medicine		E- Learning	
Lochner et al. (2016)	Italy	Speech therapy and biomedical laboratory techniques	Geral Anatomy		
Park e Howell (2015)	United States of America	Dentistry	Dental Anatomy	Flipped classroom	Its performance is similar to, or higher than, that of the traditional approaches, as well as more diversified, interactive and collaborative. It is better in terms of knowledge retention. The student is updated with the content and has more opportunities to self-assess his/her knowledge. The professor can evaluate students in terms
Obrez et al. (2011)	United States of America	Dentistry			

Kellesarian (2018)	United States of America	Dentistry			of what they have learnt, identify mistakes and help them to apply their knowledge to new clinical situations. Psychomotor abilities are enhanced. However, its methodological success depends on self-discipline, maturity and motivation. It is possible feeling the distress between expectation and course design. Lack of feedback and guidelines can compromise the method's educational effectiveness. Some students do not feel comfortable studying alone.
Shaffer (2016)	United States of America	Biological Sciences and Nursing			
Bingen et al. (2019)	Norway	Nursing			
Day (2018)	United States of America	Physical therapy	Geral Anatomy		
Whelan et al. (2016)	Canada	Medicine			
Pickering e Roberts (2017)	United Kingdom	Medicine			
Burleson e Olimpo (2016)	United States of America	Liberal Arts College	Geral Anatomy		
Mccarroll, Pohle-krauza e Martin (2009)	United States of America	Exercise Science	Skeletal Muscle	Game Based Learning	It is fun, effective and demands low costs, it also deepens the understanding about basic terms. The method is seen by students as useful for test preparation. However, students rather play with their peers and the sequence of games depends on their previous preparation. When done in conjunction with the inverted classroom, it improves engagement, further enhancing its reported effectiveness.
Rondon, Sassi e Andrade (2013)	Brazil	Speech-Language and Hearing	Head and Neck		
Ang et al. (2018)	Singapore	Medicine	Geral Anatomy		

Collett et al. (2009)	England	Medicine		Living Models	It shows anatomic variations, body surface and secondary sexuality features, reinforces humanization, and the models have active action in the teaching process. Such practice encourages students to make questions, to palpate their own bodies, and to get guided about the anatomic content. It gives individual feedback to students and tutors throughout the examination; therefore, it makes students ready to work and comfortable to deal with living bodies without embarrassment or lack of skills. Lack of living models who need to be trained to the activity is the greatest limitation of this approach.
Kugelmann et al. (2018)	Germany	Medicine	Geral Anatomy	*Magic Mirror*	Its interactive component motivates active learning and improves the 3D sense. There are impairments if a high-quality provider/software is not available.
Carnegie (2012)	Canada	Health Sciences	Geral Anatomy	Medical Poetry	It allows information accumulation rather than its mere memorization. Students also revise information about anatomy at the time to create the poems. However, the method seems to lack adhesion among students.
Dickson e Stephens (2015)	Australia	Biomedical Science	Nervous	Mimicry	Based on the traditional classes, students state that mimic classes are more interactive, pleasant, effective and motivating. The article has important limitations; therefore, the methodology must be better assessed in order to achieve more accurate results.
Samra, Wu e Redleaf (2016)	United States of America	Medicine	Hearing System	Mobile App	The method evidenced students' better performance and content exposure. It is a portable simulator (cellphone) and its design can be adjusted to the needs of students and/or of the subject. One of the method's limitations lies on the fact that when it is addressed through e-book, students can get embarrassed, but this feeling is overcome after some time using this resource.
Stirling e Birt (2014)	Australia	Medicine	Geral Anatomy		
Manyama et al. (2016)	Tanzania	Medicine	Geral Anatomy	Peer Learning	It rises the overall score of the class, a fact that mainly favors low performance students. Students have their performance enhanced, better use their time, trust each other, learn how to teach, understand the need of

Scott, Moxham e Rutherford (2014)	United Kingdom	Medicine			dominating a subject in order to teach it, and develop a professional profile and communication skills. However, students can provide inadequate teaching to the class; besides, there is the risk of turning the classes into seminars rather than into a moment to teach peers.
Fruhstorfer et al. (2011)	United Kingdom	Medicine	Geral Anatomy	Plastic Models	Based on the readings, and on case studies addressed in small groups of students and in radiologic sessions, most students classified the plastic models as the first option for effectively learning about anatomy. It allows a detailed visualization, given the quality of the dissection; it also reduces study time, since the parts are ready to be used. The method also counts on the advantage that students can visualize spatial relations and access the part at anytime, anywhere. However, the fragility and high cost of the parts inhibit students, who tend to only look at them – parts' stiffness stops the mobility of smooth tissues, it loses the natural texture and impairs students' familiarity with the experience of death. Students report that 3D printer parts do not feel like the natural part.
Naug, Colson e Donner (2011)	Australia	Medicine			
Backhouse, Taylor e Armitage (2018)	Australia	Medicine	Eyes		
Lemons (2017)	Australia	Medicine	Nervous	Practical Simulation	It promotes better understanding about anatomy, a fact that is proven by students' better performance in cognitive tests, by the better diagnostic effectiveness of physical examinations, of knowledge retention; therefore, it is very attractive to students.
Keim Janssen et al. (2014)	United States of America	Medicine	Skeletal Muscle		
Chan e Wiseman (2011)	China	Medicine	Geral Anatomy	Preceptor for one minute	Students prefer it than the traditional classes, since it addresses brief learning items, focuses on students' difficulties and promotes greater engagement in reasoning processes, as well as in the preparation for clinical learning, besides the immediate feedback.
Gross, Wright e Anderson (2017)	United States of America	Movement Science/Kinesiology	Skeletal Muscle	Quiz (software-based interactive quiz)	It is useful to visualize images of key-issues of the course, such as exam reviews; it clarifies doubts and triggers students' interest. Questions associated with images lead to better outcomes than questions linked to text reading, alone.
Huitt, Killins e Brooks (2015)	United States of America	Physical therapy	Head and neck	Team Based Learning	It promotes knowledge retention and better performance in cognitive tests than traditional methods, as well as better preparation to tests and to the development of teamwork

Vasan, Defouw e Holland (2008)	United states of America	Medicine		skills. However, it is possible finding resistance to the method due to the competition attitude among students.
Inuwa (2012)	Oman	Medicine	Geral Anatomy	
Green et al. (2016)	Australia	Exercise Science, Health Sciences, Science and Biomedical Science		



Flowchart of study selection process

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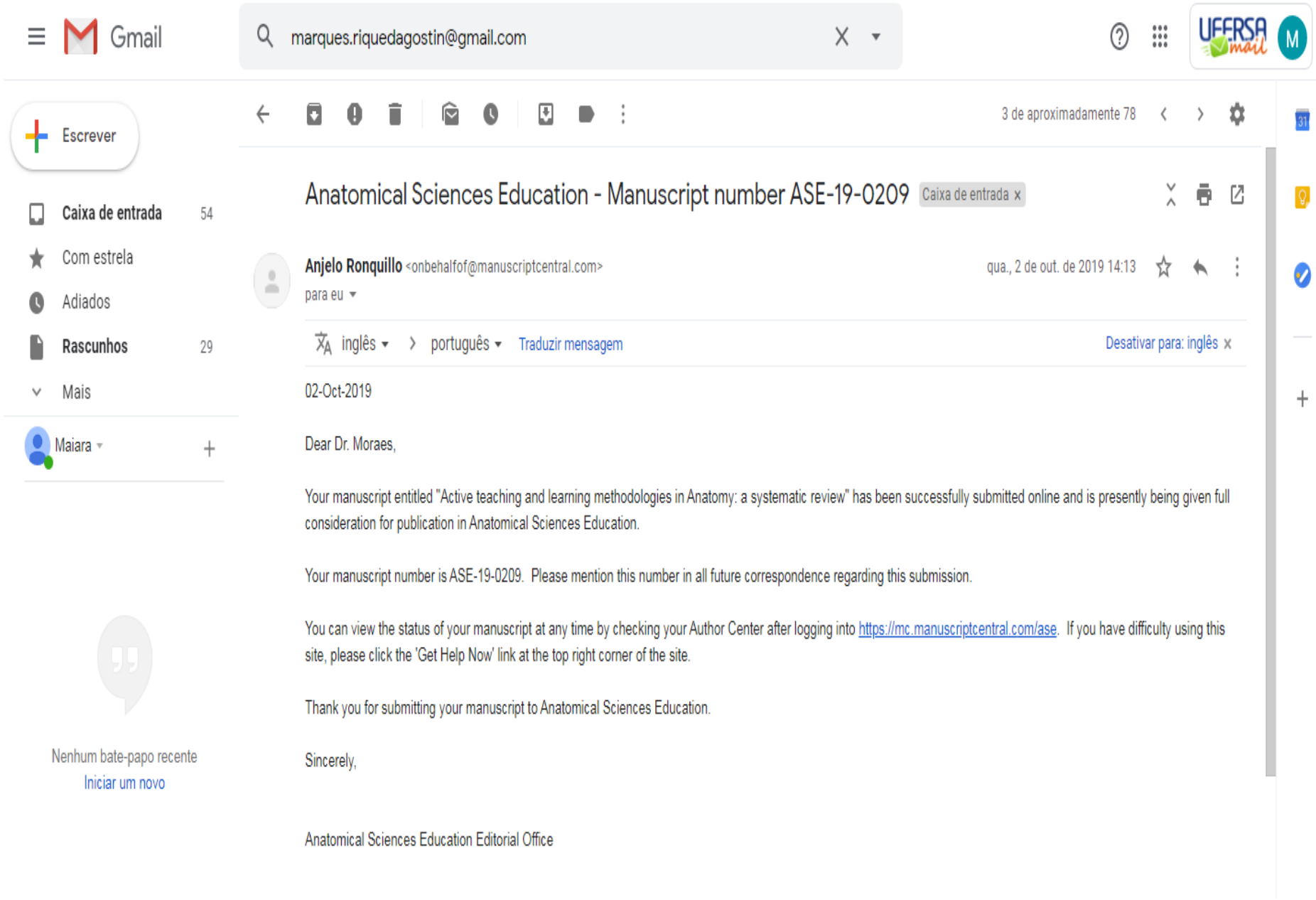
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